HISTORIC AMERICAN ENGINEERING RECORD

USCGC *MACKINAW* (WAGB-83)

HAER No. MI-121

Rig / Type of Craft:	Icebreaker
Trade:	Multi-Mission – Aiding domestic navigation, search and rescue, buoy tending, law enforcement, reserve training, and public relations.
Class:	*Mackinaw*
Principal Dimensions:	Length (oa): 290' Beam: 74'5" Draft: 19'2" Displacement: 5,252 (fl) tons (The listed dimensions are "as built," but it should be noted that draft and displacement were subject to change over time.)
Location:	Mackinaw City, MI (formerly home ported in Cheboygan, MI)
Dates of Construction:	20 March 1943 – 4 March 1944
Designer:	Gibbs and Cox in New York, NY – Commander Edward H. Thiele (USCG) supervised the design phase of the *Mackinaw*.
Builder:	Toledo Shipbuilding Company in Toledo, OH began construction, but fell into bankruptcy. American Shipbuilding and Drydock Company in Cleveland, Ohio completed the vessel.
Present Owner:	The Icebreaker *Mackinaw* Maritime Museum, Inc.
Disposition:	Historic Ship Exhibit

Significance:

When the *Mackinaw* was launched, she was the most powerful icebreaker in existence. She was specifically built for service on the Great Lakes and the only vessel built in her class. Her long service career, sixty-two years, made this ship a hero and an icon not only for the men and for women who served on her, but also for the mariners who sailed on the Great Lakes.

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Project Information:

This project is part of the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering and industrial works in the United States. The Heritage Documentation Programs of the National Park Service, U.S. Department of the Interior, administers the HAER program.

The project was prepared under the direction of Todd Croteau (HAER Maritime Program Coordinator). Gregoire Holeyman (HAER Intern Architect) generated vessel drawings. Jet Lowe (HAER photographer) created large format photographs. Special thanks are given to Commander Joe McGuiness (CO), Lieutenant Commander Lisa Mack (XO), and the crew for giving us the last tour of the *Mackinaw*. Their help and assistance greatly benefited our project.

Icebreaking on the Great Lakes began in 1872 when Alpena Harbor iced over and Commodore Louis Boynton, in St. Ignace, dispatched two ships to break up the ice. With the development of ferries used to carry rail and automobile cars across the Straits of Mackinaw, ship operators would call the ferries to assist them when they became trapped in the ice. By 1936, the U.S. Coast Guard began maintaining the shipping lanes and keeping them free from ice.[1]

The development of "true" American icebreakers, built for a single purpose, began in 1941 when President Franklin D. Roosevelt ordered the construction of the *Wind* class. The Western Pipe and Steel Company, in San Francisco, received the contract to build four icebreakers. Workers laid their keels in 1942 and constructed the four ships in two years. The construction of the *Wind* class ultimately led to the development of the *Mackinaw*.[2]

When the United States entered World War II, the U.S. Navy moved a majority of its ships to the Atlantic to counter the German U-boat threat. War planners moved two cutters, the *Escanaba* and *Tahoma*, from the Great Lakes as a result. As war production grew in the United States, so did the need for an icebreaker that could operate on the Great Lakes year round. The war effort placed heavy demands on industry and dramatically increased cargo and raw material shipments during the winter months. Consequently, Congress appropriated funding for an icebreaker to operate solely on the Great Lakes.[3]

Gibbs and Cox, naval architects in New York City, completed the design of the *Mackinaw*. The navy created a special section inside their office to design icebreakers, including the *Wind* class. The government chose Commander Edward H. Thiele, USCG, to supervise the office. Before this assignment, Commander Thiele had participated in a study on icebreakers, so his selection as supervisor of shipbuilding fit well. The naval architects prepared the working drawings for the *Mackinaw* and sent them to the shipbuilder after Commander Thiele reviewed them.[4]

The Toledo Shipbuilding Company won the contract to build the *Mackinaw* and laid the keel on 20 March 1943. Assorted delays and penalties caused the company to file bankruptcy. The American

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[1] Sandra L. Planisek, *Icebreaker Mackinaw* (Mackinaw City, MI: Great Lakes Lighthouse Keepers Association, 2006), p. 18. Planisek's book offers many insights into the *Mackinaw* from riding the vessel on and off for two years. Her book gives the reader a "personal" look into the ship and crew.

[2] Robert Erwin Johnson, *Guardians of the Sea: History of the United States Coast Guard, 1915 to the Present* (Annapolis, Md.: Naval Institute Press, 1987), pp. 214-217.

[3] "*Mackinaw* History," n.d., *Mackinaw* Cutter File, U.S. Coast Guard Historian's Office, Washington, DC, p. 1.

[4] Ibid.

Shipbuilding and Dry dock Company took over the contract and completed the *Mackinaw* for ten million dollars. The shipyard launched the *Mackinaw* on 4 March 1944 and completed her fitting out in December 1944. The U.S. Coast Guard commissioned the *Mackinaw* on 20 December 1944 and she began working on the Great Lakes thereafter.[5]

The U.S. Coast Guard intended the *Mackinaw* to make her homeport in Milwaukee, Wisconsin, but chose an alternate location in Cheboygan, Michigan. The Coast Guard determined that most of the traffic was located in and around the Straits of Mackinaw (the body of water connecting Lake Michigan and Lake Huron). The shipping lanes also included more areas: the St. Mary's River, the Soo Locks, and Whitefish Bay on Lake Superior. Consequently, Cheboygan was a natural choice close to the areas of operation.[6]

Within her design, the completed *Mackinaw* boasted an impressive array of machinery and new concepts. The shipyard constructed the *Mackinaw* out of "mild" steel and reinforced her hull with a 1-5/8 inch steel "ice belt" below the water line. Engineers employed tight frame spacing (sixteen-inches) to increase the rigidity of the hull.[7] Architects built the Mackinaw using the "Maier Ship's Form" as their basic design. The Maier Form uses triangular frames on both the bow and stern that resembled wedges and it reduces surface wetness and hull friction.[8] The model works well with icebreakers because the bow slides up on the ice and the weight of the vessel crushes it. The design also helps to protect the hull because the ice pushes it out of the water due to the curvature of the sides.[9]

Designers built the *Mackinaw* around three general characteristics: she was 292 feet in overall length, she had a 74.3-foot beam, she drew 19 feet of water, and she displaced 2,252 tons of water. Inside, six ten-cylinder Fairbanks Morse opposed-piston engines powered the ship, each rated at 2,000 horsepower. Connected to each motor were Westinghouse electric generators that sent 900-volts of direct current to three Westinghouse electric motors. Her twin-screw electric motors generated up to 5,000 shaft horsepower each for a top speed of 18 knots. Normal operations

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[5] Ibid.

[6] Ibid.

[7] "USCGC *Mackinaw* (WAGB-83)," 6 April 1967, *Mackinaw* Cutter File, U.S. Coast Guard Historian's Office, Washington, DC.

[8] *International Maritime Dictionary*, 3rd ed., s.v. "Maier Ship's Form."

[9] "USCGC *Mackinaw* (WAGB-83)," p. 1.

allowed for two main engines per shaft, although three motors could be put online per shaft. The two stern propellers were fourteen feet in diameter and had three blades.[10]

The shipyard installed an electric quadrant steering gear, built by the Hyde Windlass Company, but wear and tear on the quadrant gear began to affect the ship's ability to steer correctly. In 2000, the Coast Guard replaced the old system with a new hydraulic ram manufactured by Jastram Engineering. To protect the rudder while backing down, architects constructed an ice horn; a steel plate that projected down into the water to deflect ice away from the rudder.[11]

Naval architects chose diesel-electric propulsion over direct drive or clutched diesel engines. Several advantages were ease in maneuvering, control between forward, and reverse (icebreakers normally run into thick ice and have to back up and ram the ice to break it apart). Diesel-electrics also benefit from not having alignment problems between the engine and shaft, which adds to better compartmentalization or watertight integrity.[12]

Four Westinghouse auxiliary generators provided electrical power for the *Mackinaw*. Although the main engines used DC power, the rest of the ship used AC power. The 900-volt generators produced 1,375 kilowatts of power for multiple units: electronics, lighting, galley, pumps, refrigeration, and steering. The auxiliary generators also provided power to three Westinghouse excitation motor generators. The exciters supplied excitation to the main service generators and propulsion motors.[13]

Designers constructed the *Mackinaw* with a propeller under the overhanging bow. This concept was new to American icebreaking designs and modeled after the Swedish icebreaker *Ymer*, built in 1931. Oddly enough, Captain Thiele learned from his European investigation of icebreakers that two fundamental concepts used in the *Ymer*'s design came from American vessels, the bow propeller utilized in the Great Lakes car ferries and the diesel-electric plant from the *Northland*.[14]

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[10] *Damage Control Book: U.S. Coast Guard Cutter Mackinaw (WAGB-83)*, (Baltimore, Md.: U.S. Coast Guard Engineering Logistics Center, 2005), pp. I(a)1-2.

[11] "Engineering Study of Steering System for USCGC Mackinaw," (Portsmouth, VA: CDI Marine Company, 20 October 1998), pp. 9-19.

[12] Gregory Walsh, "Farwell to the *Mackinaw*," *Professional Mariner*, no. 6 (March-April 1994): p. 34.

[13] Ibid.

[14] Donald L. Canney, "Icebreakers and the U.S. Coast Guard," http://www.uscg.mil/hq/g-cp/history/icebreakers.html, p. 3.

Two forward Fairbanks Morse diesel-electric motors drove the bow propeller motor up to 3,300 shaft horsepower. It was similar to the stern propellers (three bladed), but slightly smaller with a diameter of twelve feet.[15]

The bow propeller on the *Mackinaw* served several useful purposes. When used ahead, the bow prop drew water from beneath the ice, which reduced the buoyancy of the ice. The weighted bow crushed the ice more efficiently because the ice losses support. Additionally, the bow's propulsive force swept the crushed ice back toward the stern and scattered the shattered it. The prop wash also helped reduce friction between the hull and the ice. Conversely, when the bow propeller was reversed the water pushed ahead of the bow moving away any snow atop the ice, thereby taking away the cushioning effect of the snow and allowing the bow direct contact with the ice.[16] Commander McGuiness used the bow propeller during docking and undocking procedures. By using the bow prop ahead and the starboard propeller in reverse, the vessel would move parallel to the dock through the torque of the screws – commonly called "walking the boat." The bow propeller was an important unit within the *Mackinaw*'s complex design.[17]

The heeling and trim tanks were another significant feature. Architects again borrowed the concept from the *Ymer* and fitted the *Mackinaw* with tanks fore and aft, as well as on the sides. The combination of tanks could be used together or separately and each set had a purpose. When beset in ice, she could draw 160 tons of water into her heeling tanks and transfer 14,700 gallons water per minute back and forth through four powerful Fairbanks-Morse pumps. The rocking motion would send the ship 10° off center every 90 seconds until she wiggled off the ice. Trim tanks in the fore and after peaks could be flooded to obtain the best angle for breaking ice and decreasing the draft to back off the ice. Piping and a strong pump connected both fore and aft trim tanks that could send 6,830 gallons of water per minute back and forth. Additionally, fuel could be stored in the trim and peak tanks adding to her immense fuel capacity.[18] Architects designed the *Mackinaw* with multiple fuel tanks able to hold 276,000 gallons.[19]

Icebreaking was the *Mackinaw*'s primary mission, but times arose when she was required to tow a vessel through the ice. The *Mackinaw* housed a large and powerful towing winch in a room on the aft deck. The Almon-Johnson constant tension-towing winch (otherwise known as "Big Bertha")

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[15] *Damage Control*, p. I(a)2.

[16] Johnson, *Guardians*, p. 215.

[17] Ibid.; Planisek, *Icebreaker*, p. 80-81.

[18] Johnson, *Guardians*, p. 215.

held 2,200 feet of 2-inch galvanized steel wire on her enormous five-foot drum. The maximum pull rating on the winch was 94,000 pounds and the breaking strength of the cable was rated at 308,000 pounds; the cable weighed 6.72 pounds per foot.[20] When crewmembers employed the winch, the cable went through a towing bit that contained a series of pullies that helped maintain the direction of the cable and reduced friction. A towing bar sat towards the aft end of the ship (all the way across the back of the ship) during a tow to prevent the cable from catching equipment protruding out. The stern had a padded rubber notch at the end of the ship to pull another vessel in close during a towing evolution.[21]

The *Mackinaw* also contained many other pieces of deck equipment around the ship. On the stern, two mooring winches handled cables for use in either a port or starboard side docking. Also on the stern was a Hiab cargo crane that could lift objects up to 1,000 pounds with a ½-inch galvanized cable and extended over the starboard side. Situated on the bow was an anchor windlass, with a chain locker below. The ship carried 810 feet of chain per anchor and two Dunn Bower anchors weighing 6,000 pounds apiece. Located amidships on the upper deck were two motorboats; a 25-foot motor surfboat sat in a cradle on the port side and a 20-foot rigid inflatable boat (RIB) sat in a cradle on the starboard side. Personnel used the RIB for law enforcement boarding, as well as search and rescue missions. A small crane at the stern of the RIB lowered or raised the boat from the water. On the aft end of the 02 level was a towing hawser that held 1,200 feet of 9 ½-inch double braided line wound around a drum.[22]

Atop the 02 level was the bridge. From the bridge, crewmembers navigated the *Mackinaw* through the Great Lakes. The navigation bridge housed an assortment of electronics (radios, GPS, Loran-C, radio directional finder, a fathometer, and radars) and the helm used to pilot the ship. A gyro repeater and compass provided bearings used for navigation. The gyrocompass was located on the main deck. On the bridge, throttles regulated the speed of the ship. The large brass handles controlled the bow prop and aft propellers through a series of linkages that were connected to vernier gauges. Air pressure was sent to the governors, which caused an increase or decrease of fuel to the engines. In turn, the generators created more or less power for the motors and the ship

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[19] "USCG *Mackinaw* (WAGB 83)," n.d., *Mackinaw* Cutter File, U.S. Coast Guard Historian's Office, Washington, D.C., p. 3.

[20] Ibid., p. 1.

[21] Planisek, *Icebreaker*, p. 32.

[22] "USCG *Mackinaw* (WAGB 83)," p. 3.

sped up or slowed down. The original engine order telegraph also sat on the bridge and could transmit the desired engine functions to the engine room in case of an emergency.[23]

Behind the bridge, on the third level, were several other rooms. The chart room, at the rear of the bridge, housed a large chart table and radar set. Behind the chartroom was the bosun mate's office and he supervised the bridge. The Coast Guard added separate conning stations on the port and starboard sides of the chartroom, on the wings of the ship, to control the ship during close maneuvers.[24]

Atop the bridge was a flying bridge. This level had various gear (searchlights, big-eye binoculars, and a satellite communication dome) and a mast that was full of electronics, which connected to the bridge equipment. While underway, a crewmember would stand as a lookout and scan ahead using the big-eye binoculars.[25]

When the *Mackinaw* began her service during World War II, the Coast Guard outfitted the vessel with ordnance. Small arms consisted of forty M-1 rifles and seventeen .45-caliber pistols. The vessel also carried two Thompson submachine guns and two .30-caliber machine guns.[26] In 2003, the Coast Guard installed an emplacement to carry an M-60 machine gun. The armory and magazine room were located on the second deck, aft of the crew's lounge.[27]

Designers centered a galley forward amidships on the main deck. They placed the crew's large mess hall on the port side of the galley and the officer's sizable wardroom on the starboard side. The chief petty officer's mess was just aft of the wardroom on the starboard side. Located on the second deck, just aft of the cargo hold, were food stores and reefers to supply the chef's needs. Modern conveniences like a cappuccino machine gave the crew added comfort.[28]

Located around the ship were quarters for the crew. Designers put the enlisted quarters on the second deck in the middle of the ship. Officer country was on the main deck, forward of frame 51,

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[23] Planisek, *Icebreaker*, pp. 73-78.

[24] Ibid., p. 71.

[25] Ibid.

[26] "Ships Characteristics," (Washington, D.C.: U.S. Coast Guard Historian's Office, n.d.), p. 1.

[27] "Historic Context Study: Decommissioning and Excessing the USCG *Mackinaw*," (Washington, DC: United States Coast Guard, August 2004), p. 5.

[28] "WAGB 83 Damage Control Diagram," Sheets 3B and 4A.

and aft of the bow storage area. Below the navigation bridge, on the 02 level, was the captain's stateroom and cabin.[29] The *Mackinaw*'s original personnel allowance called for 121 enlisted men, 3 warrant officers, and 8 commissioned officers.[30] Later, the Coast Guard reduced the enlisted personnel to 67 men and women, but kept the same number of commissioned officers.[31] The *Mackinaw*'s original crew was male, but after 2000, the Coast Guard reconfigured the ship to accommodate female enlisted personnel and officers.[32]

Through time, the appearance of the *Mackinaw* changed both internally and externally. Inside, the Coast Guard modernized the ship to improve habitability by adding, enlarging, and interchanging rooms. As technology advanced so did the equipment on board, ranging from electrical exercise equipment to self-flushing latrines. Outside, additions occurred with the construction of rooms on both sides of the towing winch room. On the afterdeck, both of the 12-ton cranes (kingposts and booms) were removed, as well as the forward masts and booms, along with their winches that serviced a number of older style boats and ice skiffs.[33] Additionally, the Coast Guard installed a sewage tank in the bow area due to tighter restrictions on the dumping of waste in the Great Lakes. This limitation restricted her endurance to roughly five days at sea.[34]

Although the *Mackinaw* was multifaceted, its key mission was icebreaking – aids to navigation. From mid-December through mid-April, ice forms on the Great Lakes. Traditionally, the icebreaking season normally starts when the ice first forms in winter and continues again in spring, ending mid-February and beginning in mid-March. The icebreaker's purpose was to extend the shipping season as much as possible. Overall, the *Mackinaw* spent around seventy days a year breaking ice.[35]

During the icebreaking season, the *Mackinaw* went through standard evolutions each year.

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[29] "WAGB 83 Damage Control Diagram," (Washington, D.C.: U.S. Coast Guard Headquarters, November 2005), Sheet 4A.

[30] "Ships Characteristics," p. 1.

[31] "USCG *Mackinaw* (WAGB 83)," p. 3.

[32] Planisek, *Icebreaker*, p. 15.

[33] "WAGB 83 Damage Control Diagram," Sheets 3B and 4A; personal visit, June 2006

[34] "U.S. Coast Guard Icebreaker Mackinaw," *The Chief Engineer*, http://www.chiefengineer.org/article.cfm?seqnum1=198.

[35] Roger Losey, "The Coast Guard Cutter Mackinaw," *The Nor'easter* 7, no. 6 (November-December 1982): p. 2.

Towards the beginning of winter, the *Mackinaw* broke ice for about six weeks until the ice became exceedingly thick. Afterward, the ship took a sabbatical, "Charlie Period," from mid-February through mid-March the crew performed scheduled maintenance. This layover gave the crew rest, as well as time to prepare for the "Spring Breakout," the opening of the shipping season.[36]

Another sequence followed each year was clearing the shipping lanes. The *Mackinaw* normally started breaking ice in Whitefish Bay (Lake Superior), then headed to the St. Mary's River to break up the ice. In Whitefish Bay, the *Mackinaw* ran long tracks back and forth to create a "super highway" for the freighters. In the lower river, the *Mackinaw* churned the ice so freighters could make turns in the bends and proceed down river without wedging themselves in the ice. When a freighter became lodged in the ice, the *Mackinaw* circled the ship – this action helped to clear the ice around freighter. The *Mackinaw* would back down on the ship ("crab walk") to tow her out of the ice using the towing winch.[37]

During icebreaking operations, the ice made certain noises and reverberated through the ship's hull. *Mackinaw* customs described the variety of ice in culinary terms: saran, mashed potato, pancake, snow cone, and margarita ice. Each individual ice form made certain sounds and produced different pulsations throughout the vessel; breaking ice was loud. There were certain rooms in the ship that required hearing protection when breaking ice due to the deafening noise the ice created while passing against the hull. Designers lined the hull with cork to act as insulation from the cold-water temperatures of the Great Lakes and it helped to buffer the noise.[38]

At the conclusion of the icebreaking season, the *Mackinaw*'s crew made necessary repairs to the ship, trained, and toured the Great Lakes promoting the U.S. Coast Guard. The Coast Guard scheduled important maintenance during this period (May-July) that could not be accomplished during "Charlie Period." From the end of July through October, the *Mackinaw* spent time instructing new crewmembers and performed public relations. Every year new personnel replaced around fifty percent of the crew and training indoctrinated the inexperienced group to the ship. In addition, every summer the *Mackinaw* navigated through the Great Lakes to promote the Coast Guard, which helped to attract new recruits. Some duties included serving as the committee boat

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[36] Planisek, *Icebreaker*, pp. 22-23.

[37] Ibid., p. 30. Although the *Mackinaw* normally operated in these general areas, it should be noted that she aided all vessels in distress on the Great Lakes and could depart to any of the five lakes to offer assistance.

[38] Ibid., p. 23. An official list of ice type and ice ages terms, as well as ice surface conditions are located in Appendix A.

for two annual sailing regattas. Lastly, towards the beginning of winter the *Mackinaw* delivered Christmas trees to Chicago, Illinois before the start of the icebreaking season.[39]

Christmas tree runs to large metropolitan areas were common in the early twentieth century and sailing ships were the principal means of transportation. This was the case with the schooner *Rouse Simmons* when it sank in 1912. She was in route to Chicago to deliver Christmas trees, but foundered during a gale. Many myths and legends surround this ship, but the idea appealed to the *Mackinaw*'s captain, CDR Jon Nickerson.[40] In 2000, he resurrected the tradition of carrying Christmas trees to Chicago under the premises: "good service for the needy, a good exercise for the crew, and to honor those lost at sea." The *Mackinaw* completed her last Christmas tree run in December 2005.[41]

A new icebreaker, also called the *Mackinaw* (WLBB-30), has replaced the original cutter. The new ship, which began service in 2005, is just as unique as the first. New technologies and automation give the cutter multi-mission capabilities. Her primary assignment is icebreaking, but she will also be able to perform buoy tending, search and rescue, marine environmental response, and maritime law enforcement. The new systems on board allow her to carry less crew and give her more endurance.[42]

The *Mackinaw*'s long service career, sixty-two years, enabled her to make a special mark upon the mariners of the Great Lakes by responding to vessels in distress. In one operation, the *Mackinaw* traveled to Buffalo to assist twelve ice-bound vessels on 17-18 March 1948. This marked the first time in fifty years that the shipping lanes to Buffalo opened before the spring thaw. She aided two vessels (M/V *Cedarville* and M/V *Topdalsfajord*) on 10 May 1965 that collided a mile northeast of Mackinaw City, Michigan. The *Mackinaw* has helped vessels aground, such as when she ferried twenty-nine crewmembers from the M/V *Nordmeer* to Alpena, Michigan on 21 November 1966 and she freed the stranded M/V *Stadocona* on 1 April 1970. On 13 April 1984, the *Mackinaw* aided twelve vessels beset in the St. Clair River, afterwards she proceeded to Lake St. Claire to break an ice jam that inhibited navigation and had flooded Marine City, Michigan. On Lake Superior, in March 1991, the *Mackinaw* broke a section of windrow ice near Duluth, Minnesota that had trapped three ships. Throughout her long career, the *Mackinaw* assisted many ships in need. Her reputation

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[39] Ibid.

[40] http://christmastreeship.homestead.com/SchuenemannBrothers.html

[41] Planisek, *Icebreaker*, pp. 2-3.

among the Great Lakes' ships was impeccable and sailors always knew that they could rely on the *Mackinaw* for help.[43]

Today, the *Mackinaw* is a floating museum located in Mackinaw City, Michigan (the town for which she was named after). The U.S. Coast Guard turned the ship over in July 2006 to the Icebreaker *Mackinaw* Maritime Museum. Currently, the museum is developing exhibits for the public so they can tour the ship and glean knowledge from the *Mackinaw*'s long career.

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[42] "USCGC *Mackinaw* (WLBB-30)," n.d., *Mackinaw* Cutter File, U.S. Coast Guard Historian's Office, Washington, DC, p. 2.

[43] Ibid., p. 3.

Appendix A

Ice Type Terms

Field - An area of pack ice consisting of any size of floes that is greater than ten kilometers across.

Pancake - Predominantly circular pieces of newly formed ice from three meters in diameter, and up to nine centimeters in thickness, with raised rims due to collisions.

Floe - Any relatively flat piece of ice ten meters or more across. A floe may consist of a single unbroken fragment or many consolidated fragments.

Cake - Any relatively flat piece of ice less than ten meters across. Cake implies a single unbroken fragment of ice.

Brash - Accumulations of floating ice made up of fragments not more than 2 meters across, the wreckage of other forms of ice.

Slush - Snow, which is saturated and mixed with water, a viscous floating mass in water after a heavy snowfall. It is an accumulation of ice crystals, which may or may not be slightly frozen together. Slush has no degree of hardness.

Fast/Shore - Stretches of unbroken ice, which is fast to the shore.

Ice Age Terms

Blue - Fairly level, flat sheet of clear ice, blue appearance, may be fast.

White - First stage of thawing or ice formed largely of snow.

Rotten - Honeycombed due to melting needle ice.

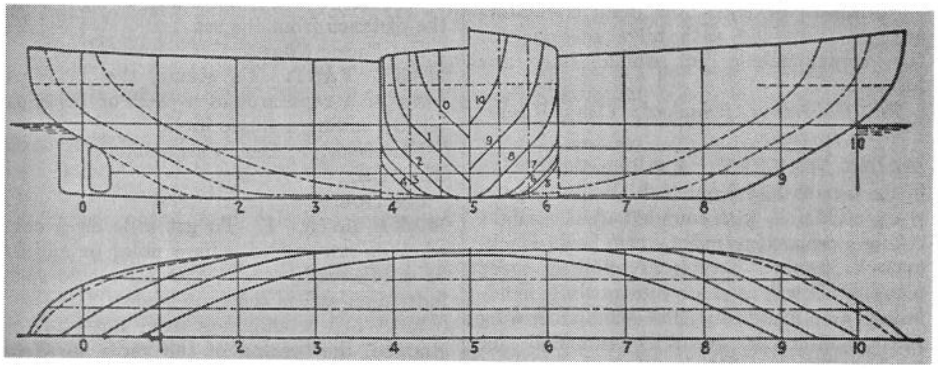
Ice Surface Conditions

Windrow - Ice which has been pressed into heavy ridges or layers by strong winds, often piled up against the shore or other obstruction.

Jammed - (1) An accumulation of broken river ice in a narrow channel. (2) Fields of lake ice separated from the shores in early spring may be blown against the shore, exerting great pressures. In addition, masses of broken-up ice may drift with the wind and produce jams on and against the shore.

Appendix B

Historic Blueprint and Photographs



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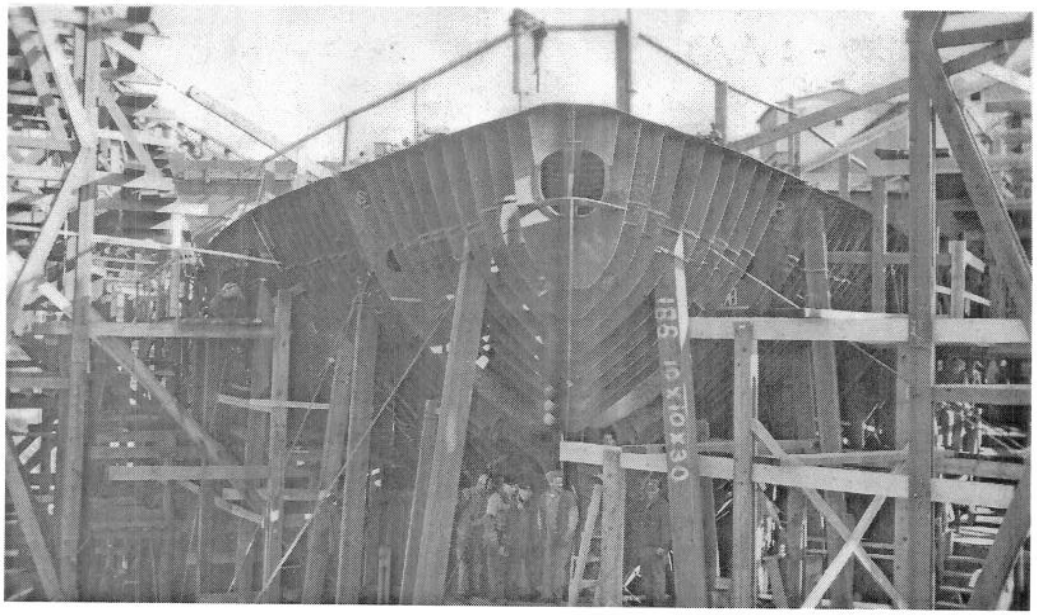
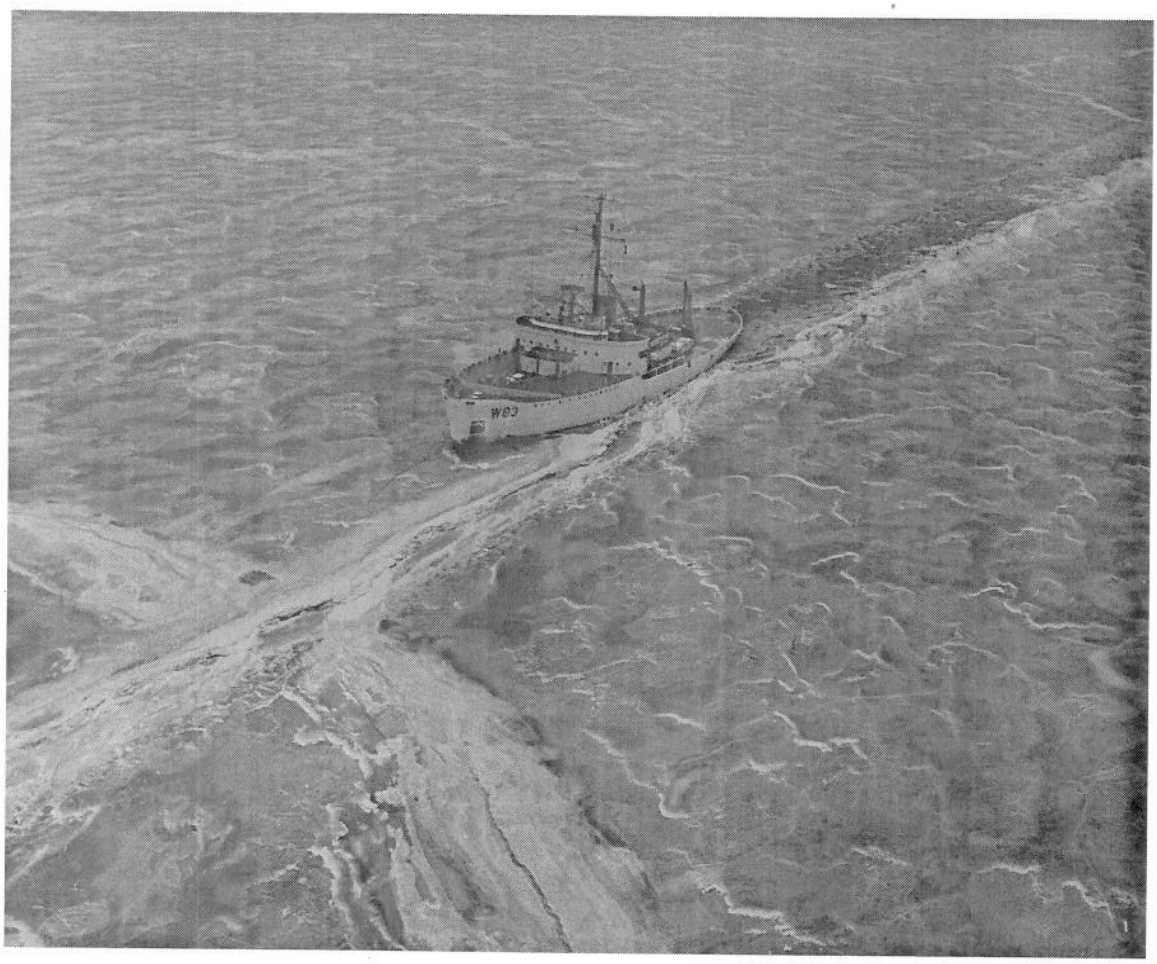
International Maritime Dictionary, 3rd ed.



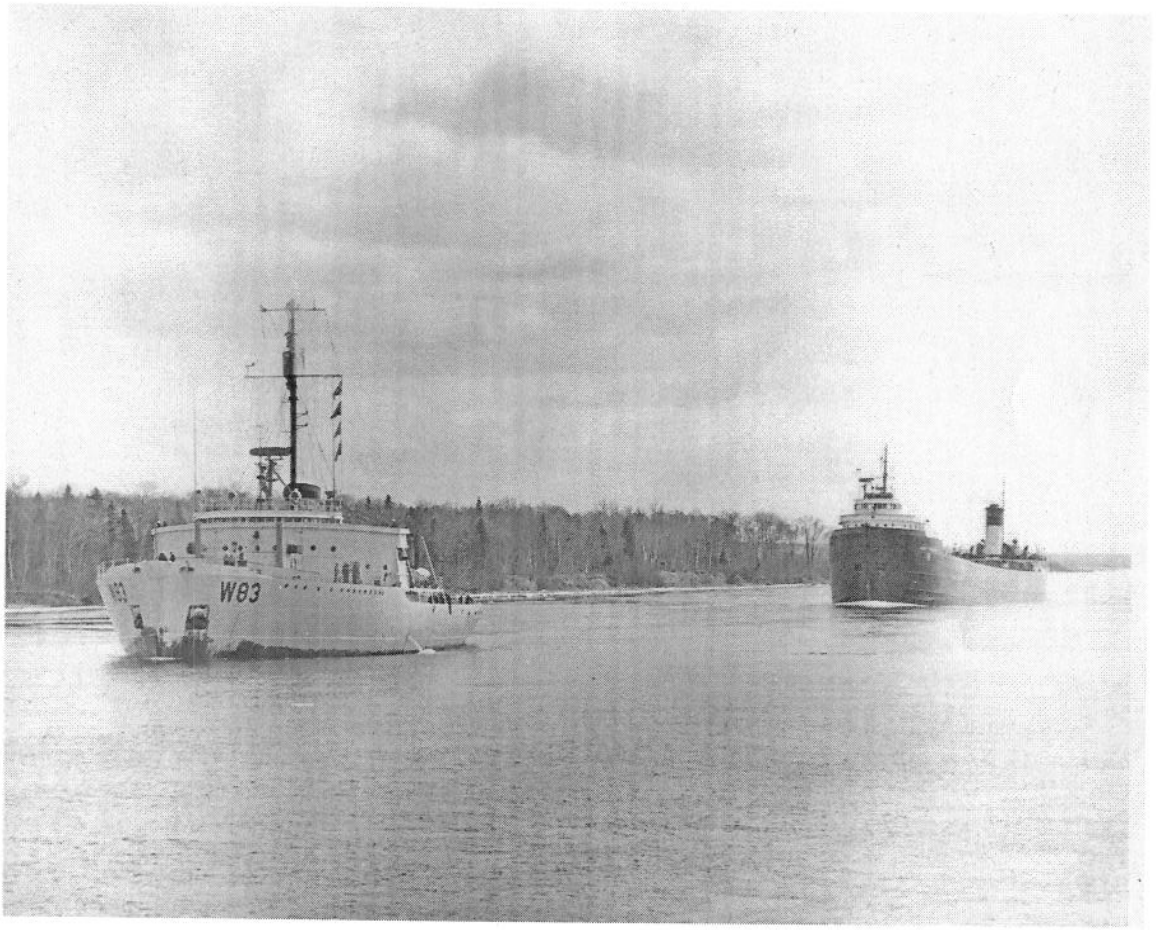
Bow view of the *Mackinaw* under construction, 8 October 1943
U.S. Coast Guard Historian's Office, *Mackinaw* Files

Mackinaw breaking ice on a trial run, 1944
U.S. Coast Guard Historian's Office, *Mackinaw* Files

Trial run through heavy winter weather on Lake Huron, 1944
U.S. Coast Guard Historian's Office, *Mackinaw* Files.

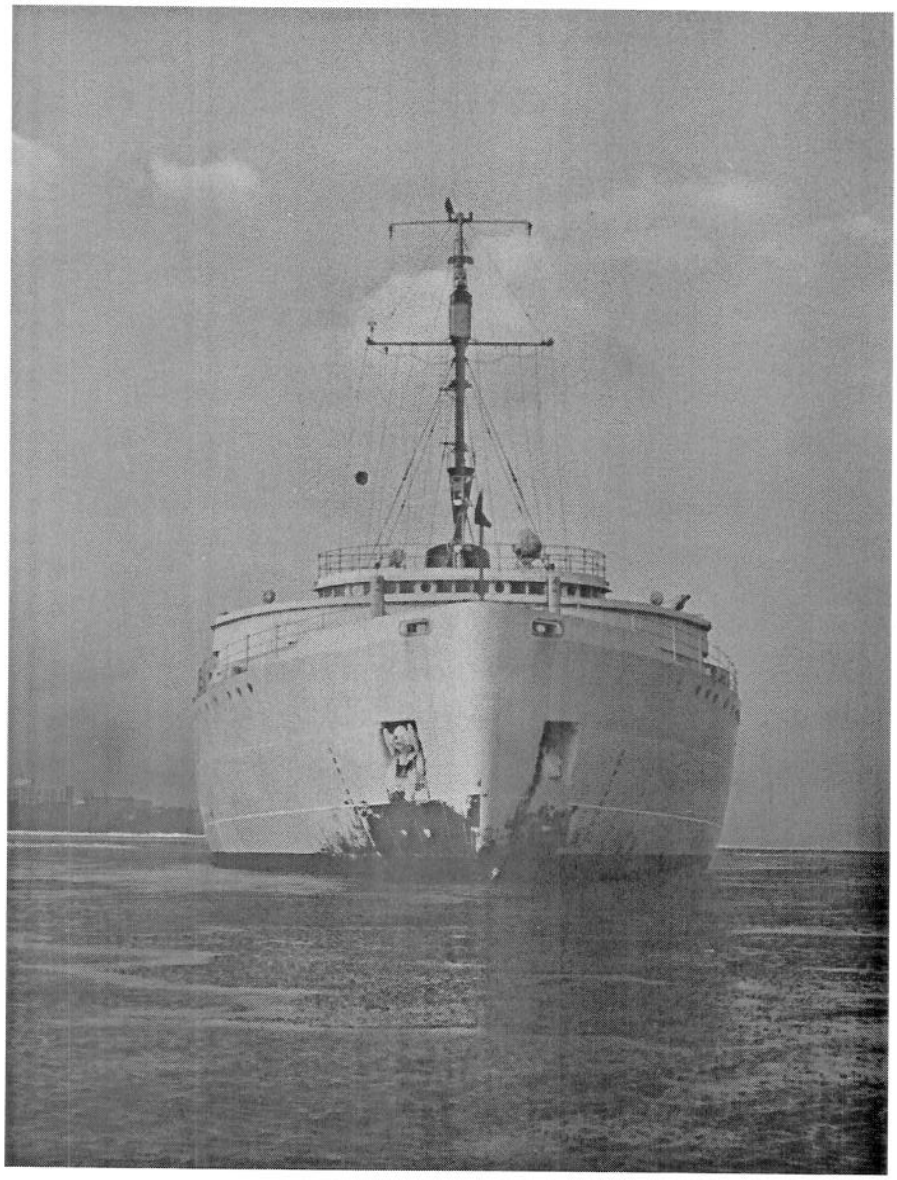


Mackinaw breaking through windrow ice on the St. Mary's River, 15 March 1966
U.S. Coast Guard Historian's Office, *Mackinaw* Files

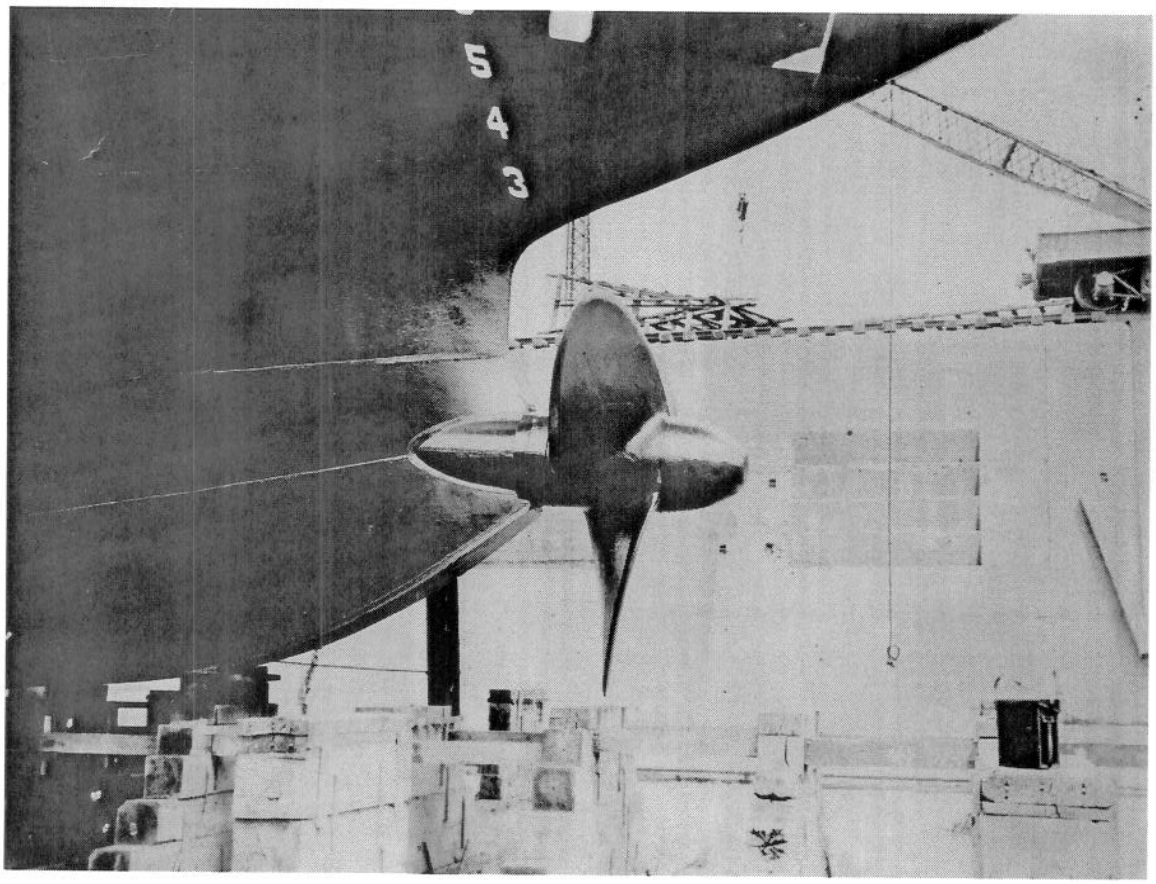


Mackinaw leading an ore freighter through the St. Mary's River, 15 March 1966
U.S. Coast Guard Historian's Office, *Mackinaw* Files

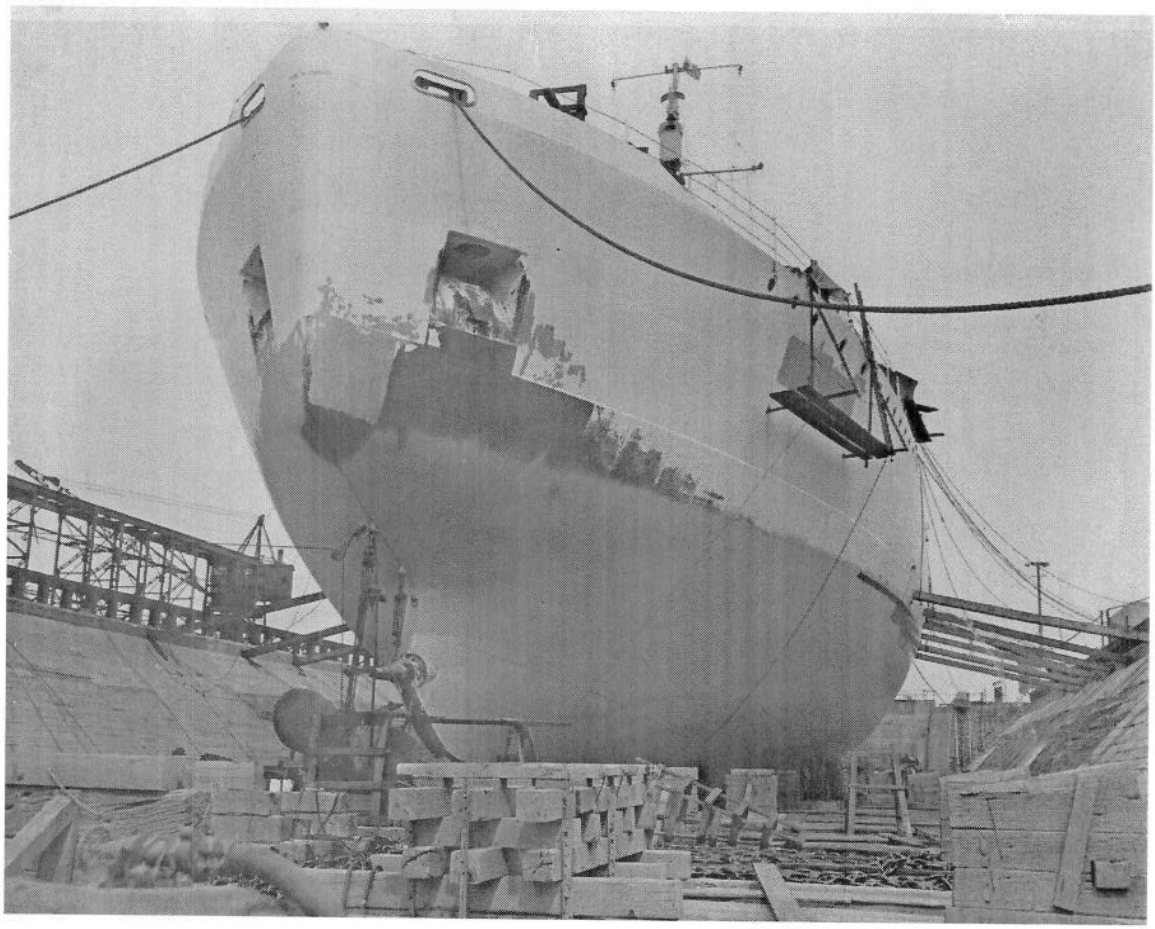
Mackinaw creating tracks on the Great Lakes, n.d.
U.S. Coast Guard Historian's Office, *Mackinaw* Files



Bow view of the *Mackinaw* underway, n.d.
U.S. Coast Guard Historian's Office, *Mackinaw* Files



Starboard view of the *Mackinaw*'s bow propeller, n.d.
U.S. Coast Guard Historian's Office, *Mackinaw* Files



View of the *Mackinaw*'s port bow while in dry dock, n.d.
U.S. Coast Guard Historian's Office, *Mackinaw* Files

View of the *Mackinaw*'s port quarter while in dry dock, n.d.
U.S. Coast Guard Historian's Office, *Mackinaw* Files

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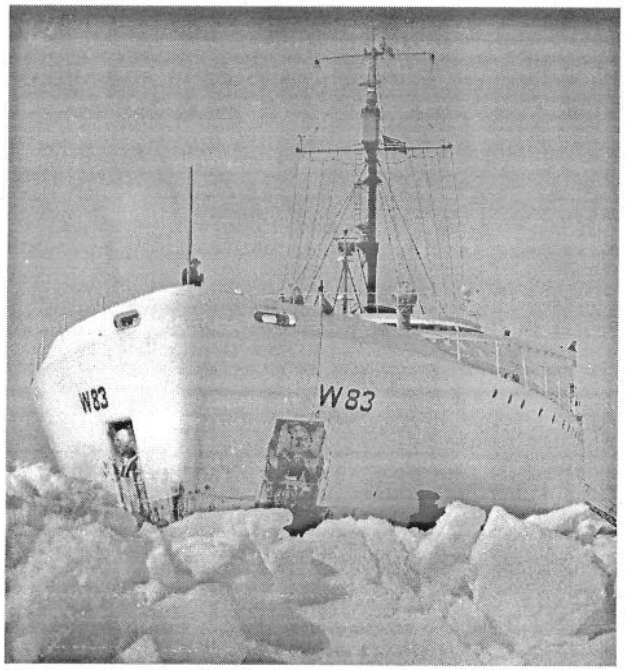
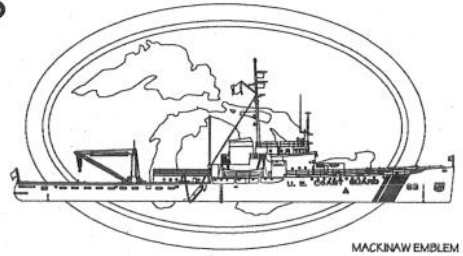
ICEBREAKER USCG MACKINAW (WAGB 83)

"THE QUEEN OF THE GREAT LAKES"

USCG EMBLEM



OFFICIAL USCG PHOTO: 062559-07

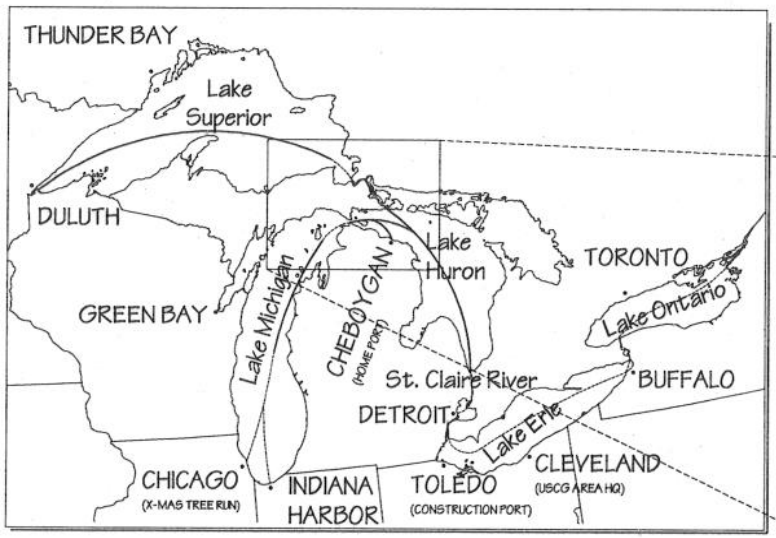


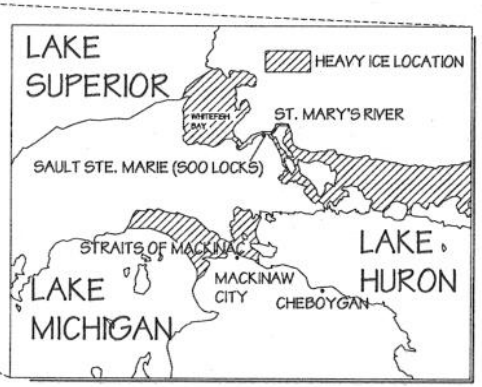
MACKINAW EMBLEM

When the United States entered into the Second World War, the U.S. Navy moved a majority of its ships to the Atlantic to counter the German U-boat threat. Two icebreakers, the *Escanaba* and *Tahoma*, were moved from the Great Lakes as a result. As war production grew in the United States, so did the need for an icebreaker that could operate on the Great Lakes year round. The war effort placed heavy demands on industry that required increases in cargo carrying raw materials to the factories during the winter months. Consequently, Congress appropriated funding for an icebreaker to operate solely on the Great Lakes.

When the *Mackinaw* was launched, she was the most powerful icebreaker in existence. She was specifically built for service on the Great Lakes and the only vessel built in her class. Her long service career, sixty-two years, made this ship a hero and an icon for the men and women who not only served on her, but also for the mariners that sailed on the Great Lakes.

Today, the *Mackinaw* is a floating museum located in Mackinaw City, Michigan (the town for which she was named after). The U.S. Coast Guard released the ship to the Icebreaker *Mackinaw* Maritime Museum in July 2006. Currently, the museum is developing exhibits for the public so they can tour the ship and glean knowledge from the *Mackinaw*'s long career.





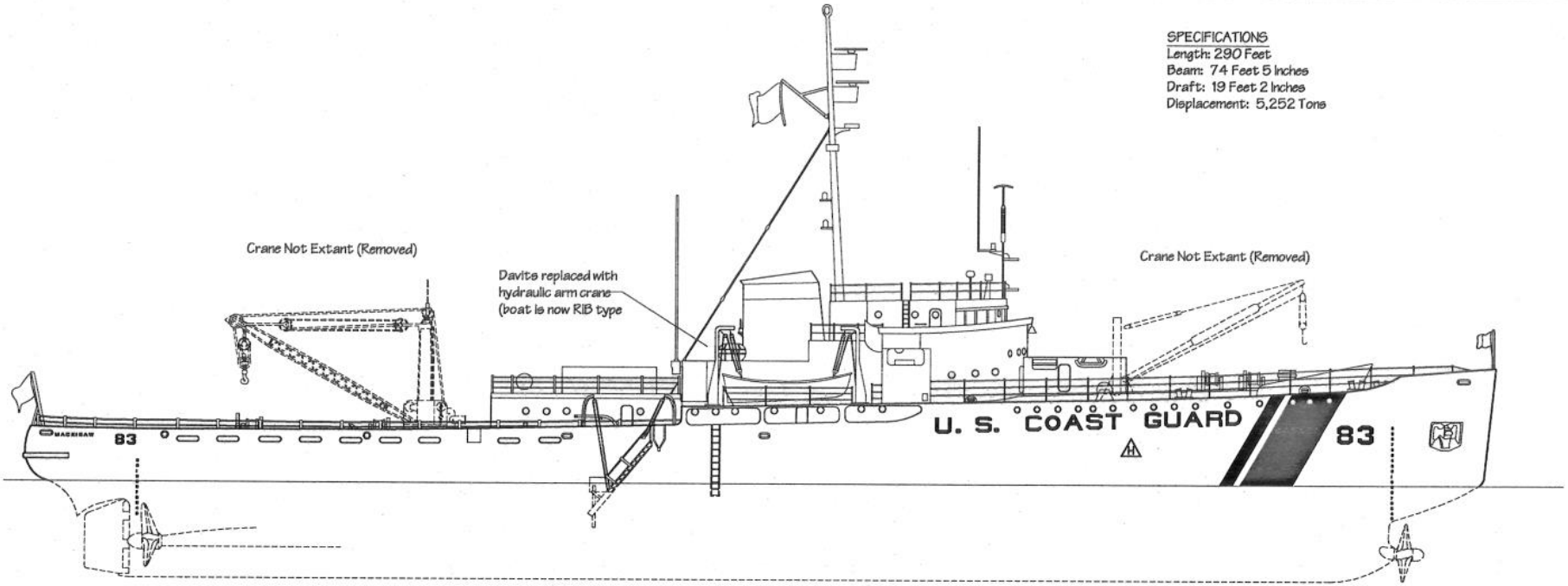
DETAIL MAP OF THE MACKINAW'S REGIONAL ICE BREAKING AREA

This project was prepared under the direction of HAER Maritime Program Coordinator, Todd Croteau and USCG Environmental Officer, Susan Hathaway. Brian Clayton, Contract Historian, prepared the historical narrative. Gregoire Holeyman, HAER Intern Architect, generated vessel drawings. Jet Lowe, HAER photographer, created large format photographs. Special thanks are given to Commander Joe McGuiness and Lieutenant Commander Lisa Mack for giving us the last tour of the Mackinaw. Their help and assistance greatly benefited our project.

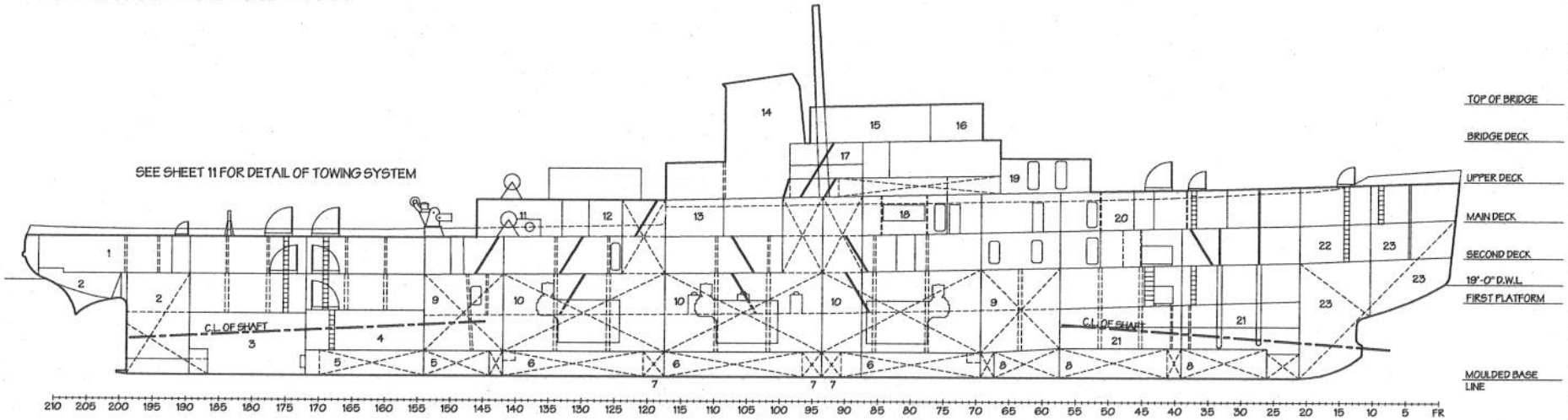
The *Mackinaw* was documented during its final days with the Coast Guard in Cheboygan, MI. The vessel was to be transferred to a musuem group and relocated to Mackinaw City, MI upon being decomissioned in 2006.

MACKINAW (WAGB 83)
ICEBREAKER
CHEBOYGAN COUNTY
MICHIGAN
SHEET 1 OF 11
HISTORIC AMERICAN ENGINEERING RECORD MI-121
CHEBOYGAN
DELINEATED BY: GREGOIRE HOLEYMAN
HAER MARITIME PROGRAM
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

SPECIFICATIONS
Length: 290 Feet
Beam: 74 Feet 5 Inches
Draft: 19 Feet 2 Inches
Displacement: 5,252 Tons

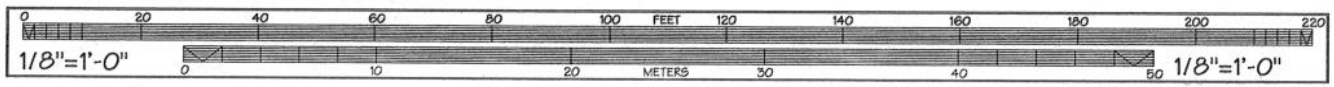


OUTBOARD PROFILE



INBOARD PROFILE

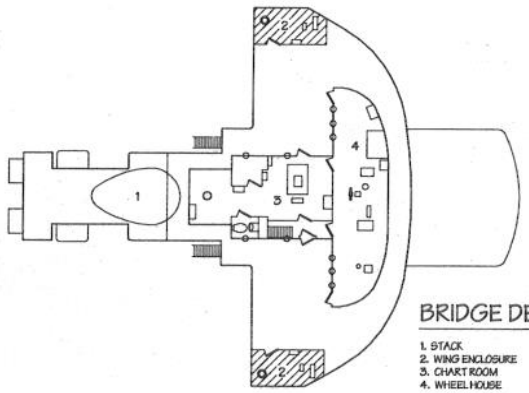
1. STEERING GEAR ROOM
2. AFTER PEAK TRIM TANK
3. TRIM TANK
4. PUMP ROOM
5. BALLAST TANK
6. DIESEL OIL TANK
7. ICE BOX
8. POTABLE WATER TANK
9. MOTOR ROOM
10. GENERATOR ROOM
11. TOWING WINCH ROOM
12. CREWS MESS
13. TOWING MOTOR GENERATOR ROOM
14. STACK
15. CHART ROOM
16. WHEEL HOUSE
17. RADIO CENTRAL
18. GALLEY
19. WINCH ROOM
20. GYRO ROOM
21. SHAFT ALLEY
22. CHAIN LOCKER
23. FORE PEAK TRIM TANK



NOTE: DRAWINGS HAVE BEEN TRACED FROM ORIGINAL 1943 CONSTRUCTION PLANS BY THE USCG

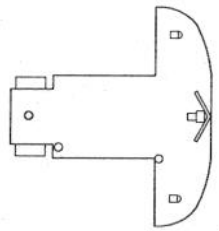
MACKINAW (WAGB 83)
CHEBOYGAN COUNTY
MICHIGAN
SHEET 2 OF 11
HISTORIC AMERICAN ENGINEERING RECORD MI-127
CHEBOYGAN
DELINEATED BY: GREGOIRE HOLEYMAN
HAER MAR-TUNE RECORDING PROGRAM NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

UPPER DECK PLANS

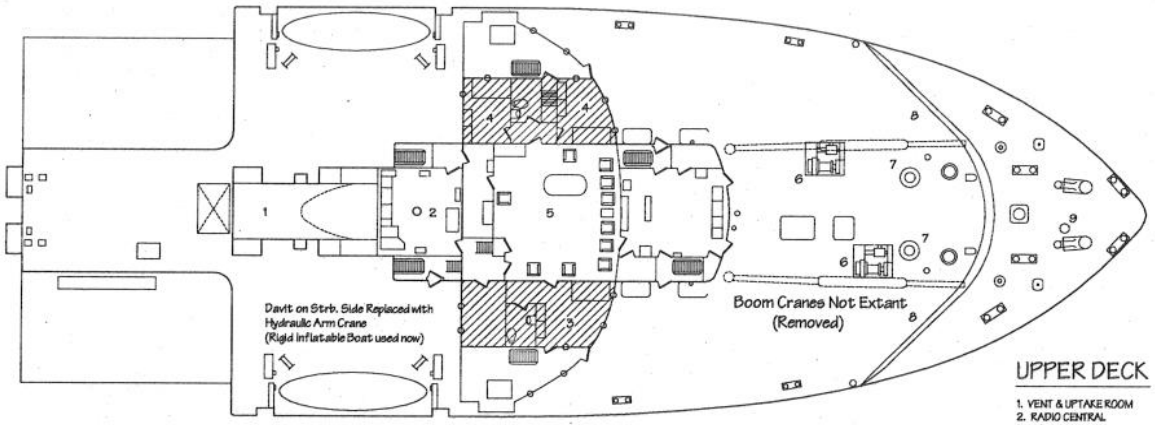


BRIDGE DECK

1. STACK
2. WING ENCLOSURE
3. CHART ROOM
4. WHEEL HOUSE



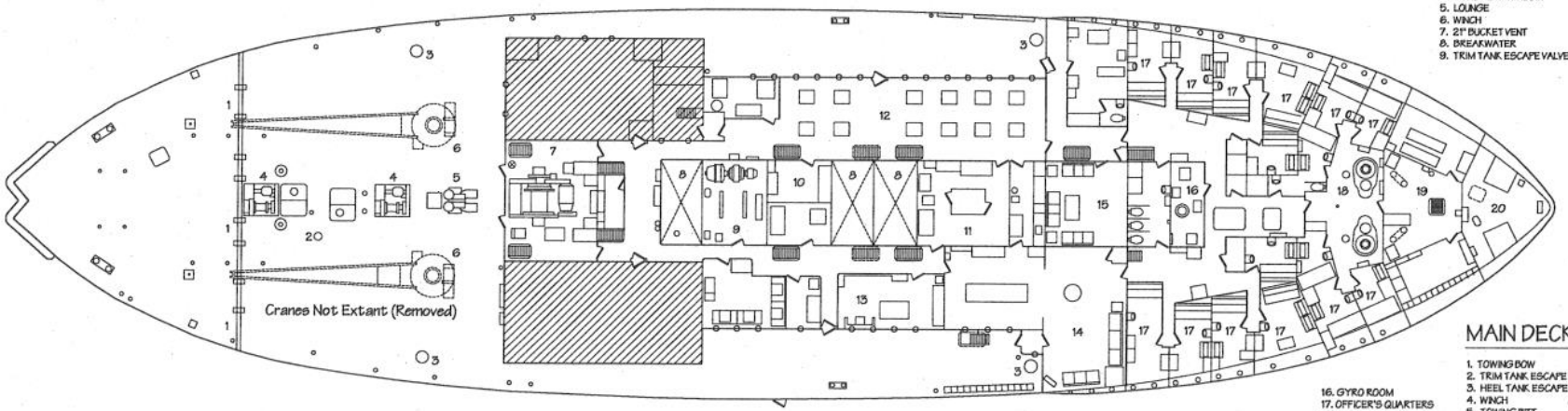
TOP OF BRIDGE



ADDITION TO ORIGINAL SHIP LAYOUT

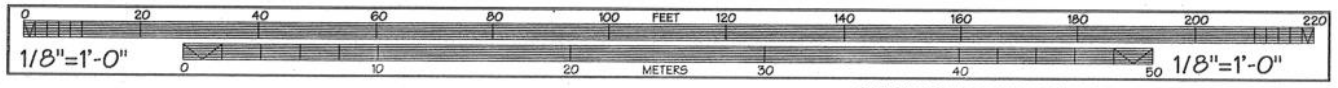
UPPER DECK

1. VENT & UPTAKE ROOM
2. RADIO CENTRAL
3. COMMANDING OFFICER STATEROOM
4. GUEST STATEROOM
5. LOUNGE
6. WINCH
7. 21" BUCKET VENT
8. BREAKWATER
9. TRIM TANK ESCAPE VALVE



MAIN DECK

1. TOWING BOW
2. TRIM TANK ESCAPE VALVE
3. HEEL TANK ESCAPE VALVE
4. WINCH
5. TOWING BITT
6. KINGPOST & BOOM
7. TOWING WINCH ROOM
8. VENT TRUNK
9. TOWING MOTOR GENERATOR ROOM
10. SCULLERY
11. GALLEY
12. CREW'S MESS ROOM
13. CPO MESS ROOM
14. WARD ROOM
15. CREW'S LIBRARY
16. GYRO ROOM
17. OFFICER'S QUARTERS
18. WINDLASS ROOM
19. TRUNK
20. LAMP ROOM



NOTE: DRAWINGS HAVE BEEN TRACED FROM ORIGINAL 1943 CONSTRUCTION PLANS BY THE USCG

MACKINAW (WAGB 83)
MACKINAW CLASS ICEBREAKER
CHEBOYGAN COUNTY
MICHIGAN

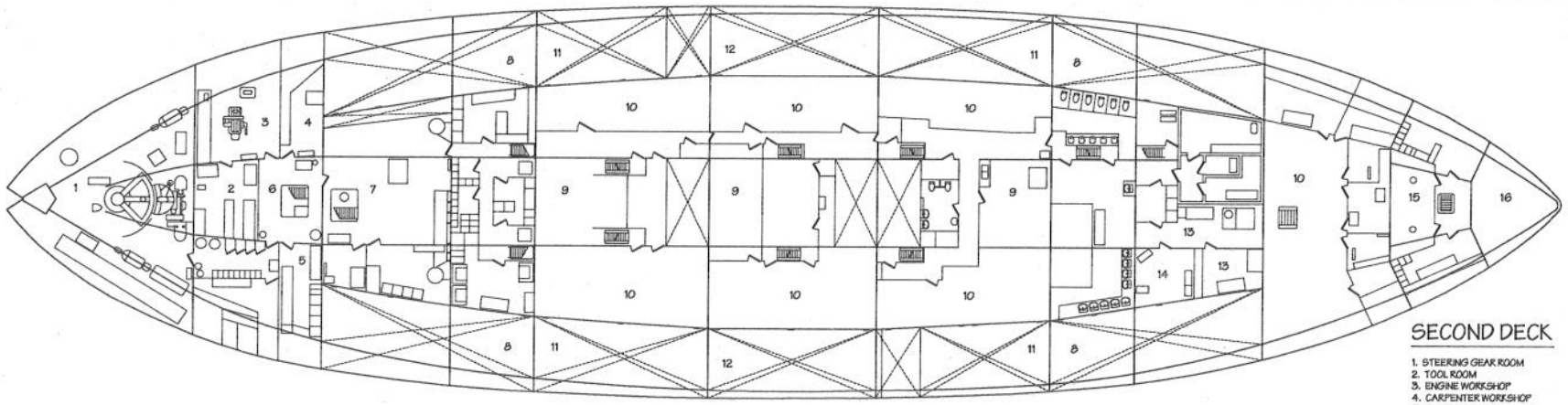
SHEET 3 OF 11

HISTORIC AMERICAN ENGINEERING RECORD MI-121

DELINEATED BY: GREGOIRE HILEYMAN

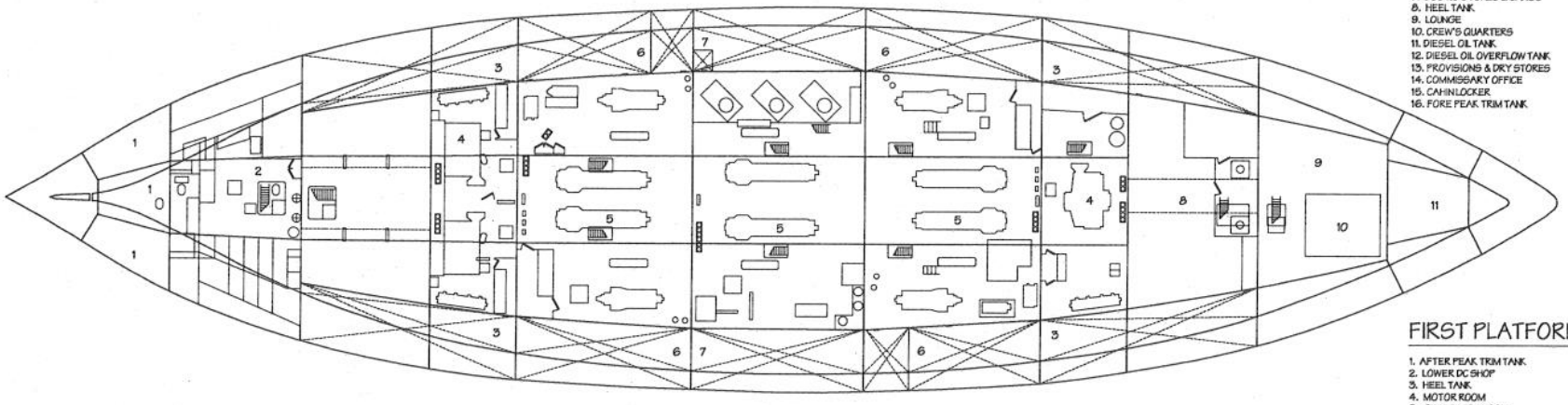
HAER MARITIME RECORDING PROGRAM
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

CHEBOYGAN



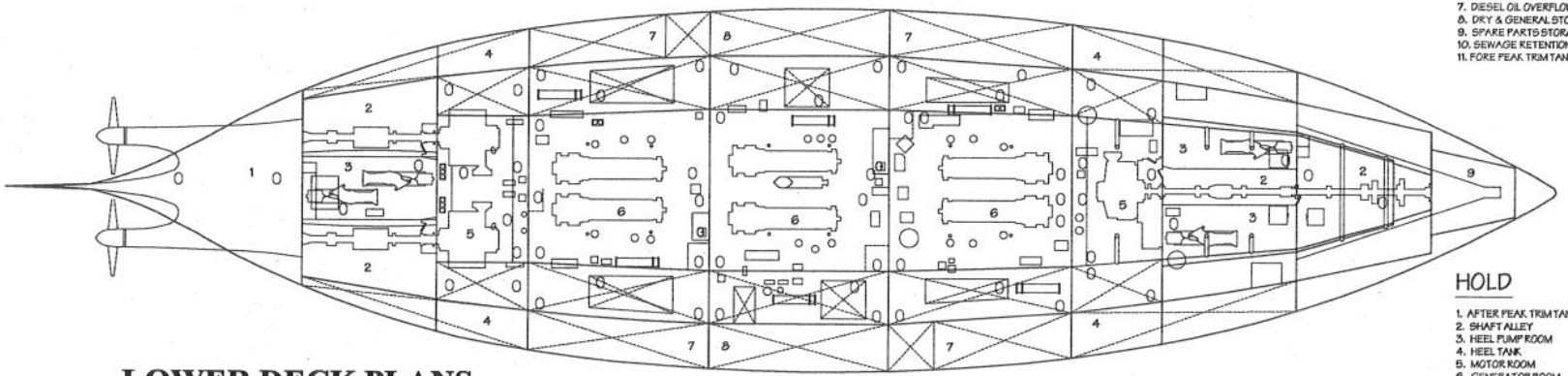
SECOND DECK

1. STEERING GEAR ROOM
2. TOOL ROOM
3. ENGINE WORKSHOP
4. CARPENTER WORKSHOP
5. ELECTRICITY WORKSHOP
6. TRUNK
7. BOSN'S STORES & CARGO
8. HEEL TANK
9. LOUNGE
10. CREW'S QUARTERS
11. DIESEL OIL TANK
12. DIESEL OIL OVERFLOW TANK
13. PROVISIONS & DRY STORES
14. COMMISSARY OFFICE
15. CAHIN LOCKER
16. FORE PEAK TRIM TANK



FIRST PLATFORM

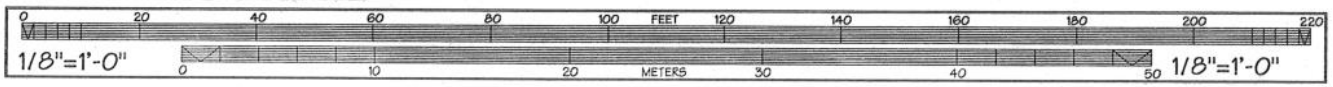
1. AFTER PEAK TRIM TANK
2. LOWER DC SHOP
3. HEEL TANK
4. MOTOR ROOM
5. GENERATOR ROOM
6. DIESEL OIL TANK
7. DIESEL OIL OVERFLOW TANK
8. DRY & GENERAL STORES
9. SPARE PARTS STORAGE
10. SEWAGE RETENTION TANK
11. FORE PEAK TRIM TANK



HOLD

1. AFTER PEAK TRIM TANK
2. SHAFT ALLEY
3. HEEL PUMP ROOM
4. HEEL TANK
5. MOTOR ROOM
6. GENERATOR ROOM
7. DIESEL OIL TANK
8. DIESEL OIL OVERFLOW TANK
9. FORE PEAK TRIM TANK

LOWER DECK PLANS



NOTE: DRAWINGS HAVE BEEN TRACED FROM ORIGINAL 1943 CONSTRUCTION PLANS BY THE USCG

MACKINAW (WAGB 83)
ICEBREAKING TUG
CHEBOYGAN COUNTY
MICHIGAN

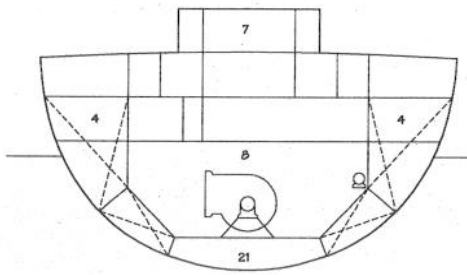
SHEET 4 OF 11

HISTORIC AMERICAN ENGINEERING RECORD MI-121

DELINEATED BY: GREGOIRE HOLEYMAN

HABS/HAER/HALS RECORDING PROGRAM
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

CHEBOYGAN



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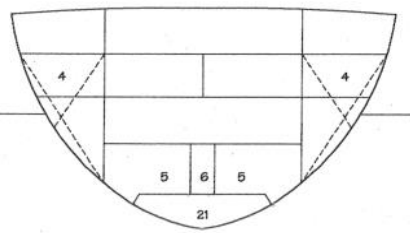
LOOKING FOR'D



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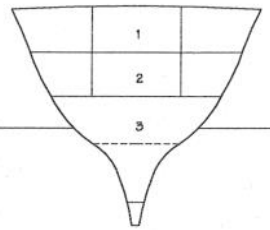
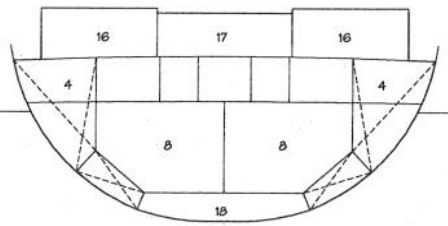
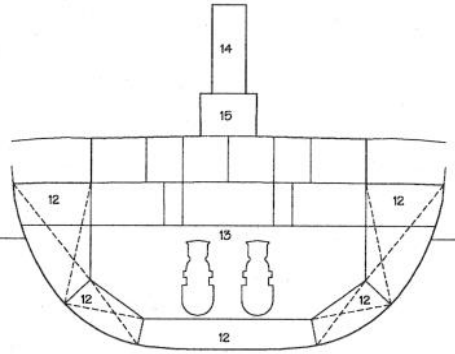


FRAME 16
LOOKING FOR'D

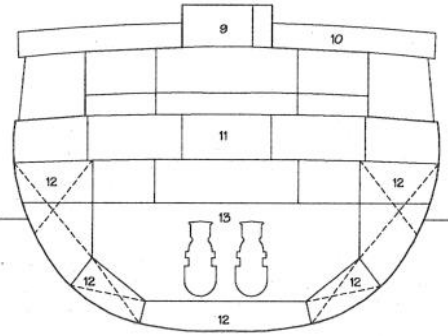
BRIDGE DECK
UPPER DECK
MAIN DECK
SECOND DECK
19'-0" D.W.L.
FIRST PLATFORM
MOULDED BASE LINE



FRAME 143
LOOKING AFT



FRAME 106
LOOKING AFT

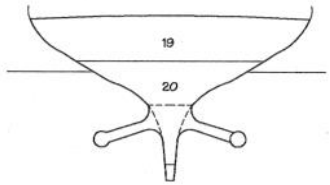


FRAME 80
LOOKING FOR'D

TOP OF BRIDGE
BRIDGE DECK
UPPER DECK
MAIN DECK
SECOND DECK
19'-0" D.W.L.
FIRST PLATFORM
MOULDED BASE LINE

CROSS SECTIONS

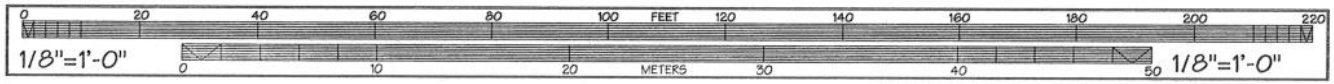
1. TRUNK
2. CHAIN LOCKER
3. FORE PEAK TRIM TANK
4. HEEL TANK
5. HEEL PUMP ROOM
6. SHAFT ALLEY
7. WINCH ROOM
8. MOTOR ROOM
9. CHART ROOM
10. SHIELD
11. GALLEY
12. DIESEL OIL TANK
13. GENERATOR ROOM
14. STACK
15. VENT & UPTAKE SPACE
16. DECKHOUSE EXTENSION
17. TOWING MOTOR ROOM
18. BALLAST TANK
19. STEERING GEAR ROOM
20. AFTER PEAK TRIM TANK
21. POTABLE WATER TANK



FRAME 193
LOOKING AFT

MAIN DECK
SECOND DECK
19'-0" D.W.L.
FIRST PLATFORM
MOULDED BASE LINE

CROSS SECTIONS



NOTE: DRAWINGS HAVE BEEN TRACED FROM ORIGINAL 1943 CONSTRUCTION PLANS BY THE USCG

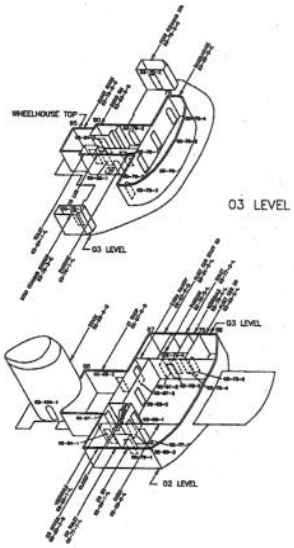
MACKINAW (WAGB 83)
133' GREAT LAKES ICEBREAKER
CHEBOYGAN COUNTY
MICHIGAN

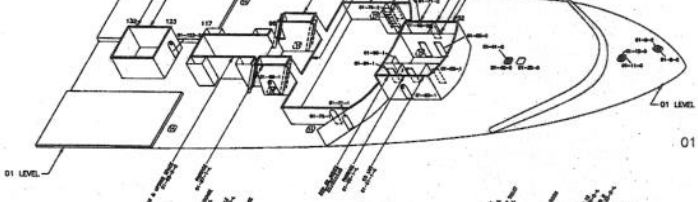
SHEET 5 OF 11

HISTORIC AMERICAN ENGINEERING RECORD MI-121

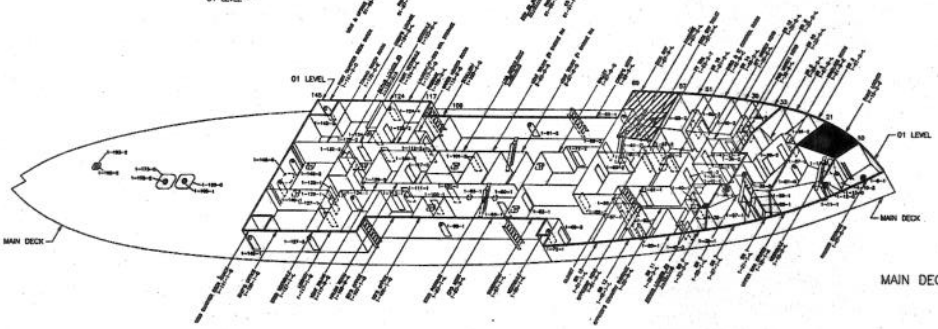
CHEBOYGAN

DELINEATED BY: GREGOIRE HOLEYMAN
HISTORIC MARITIME BUILDINGS PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

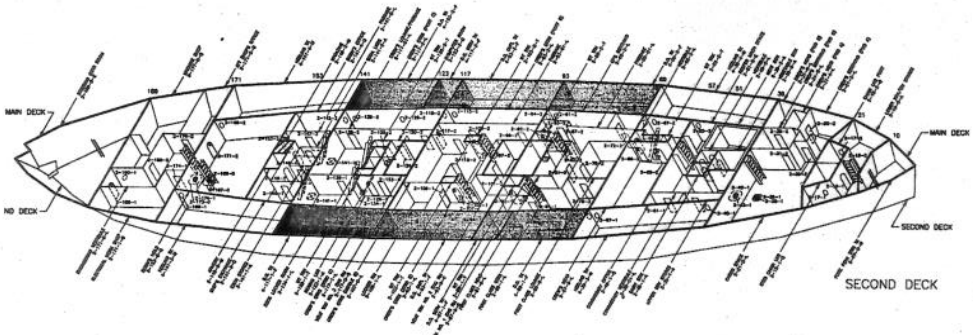




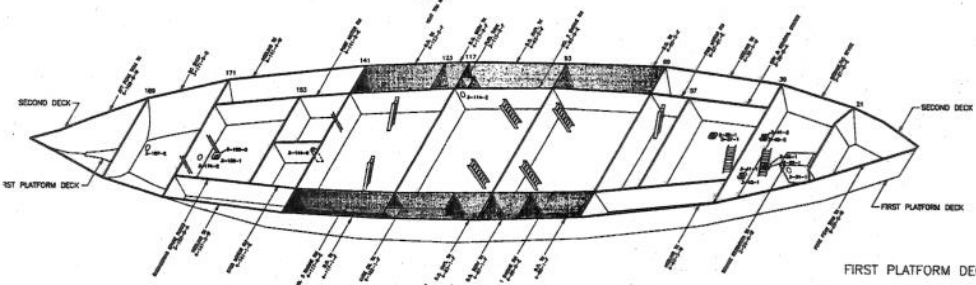
01 LEVEL



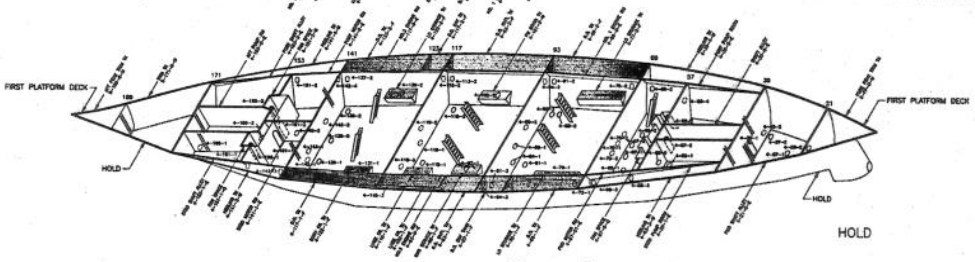
MAIN DECK



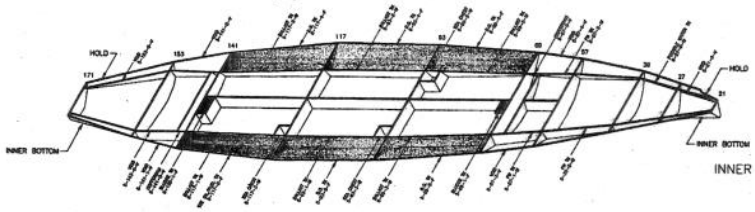
SECOND DECK



FIRST PLATFORM DECK



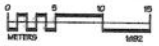
HOLD



INNER BOTTOM

DECK SCHEMATICS

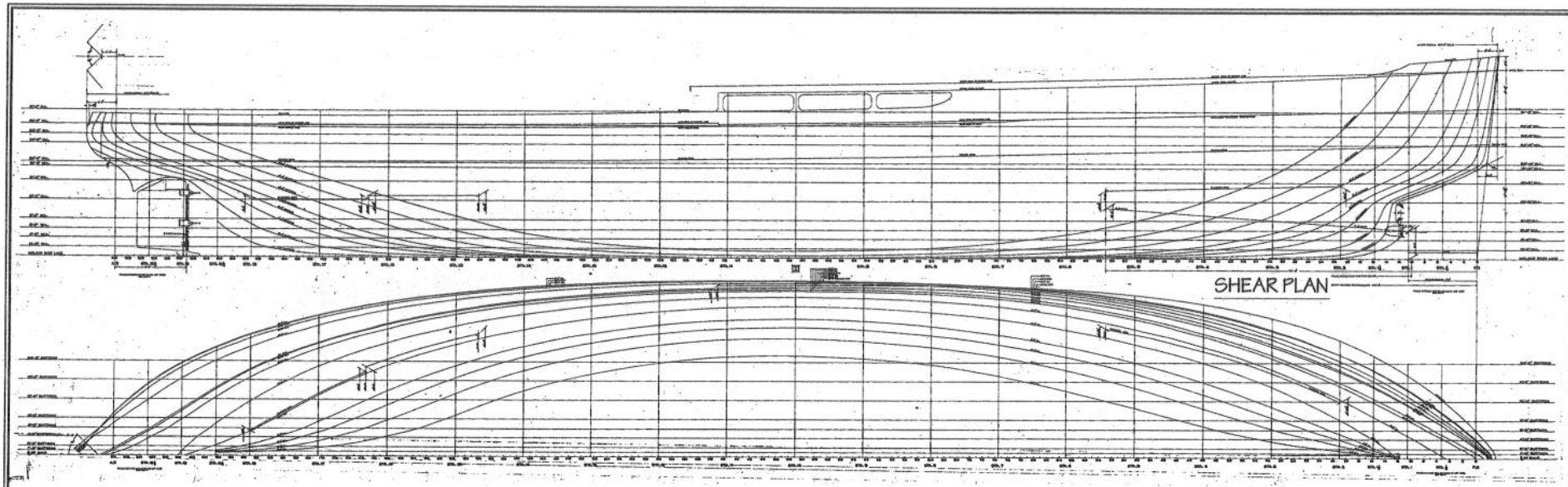
SCALE: 1/16" = 1'-0"



NOTE: IMAGE SCANNED FROM ORIGINAL PLATE SET OF THE CGC MACKINAW

DELINEATED BY: GREGOIRE HOLEYMAN

HAER MARITIME RECORDING PROGRAM NATIONAL PARK SERVICE UNITED STATES DEPARTMENT OF THE INTERIOR	CHEBOYGAN	MACKINAW (WAGB 83) 632 COAST GUARD DRIVE CHEBOYGAN COUNTY	MICHIGAN	SHEET 6 OF 11	HISTORIC AMERICAN ENGINEERING RECORD MI-121



SHEAR PLAN

HALF-BREADTH PLAN

WATER LINES
HALF BREADTHS

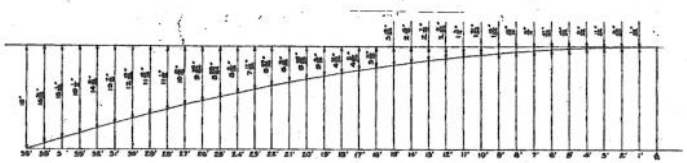
STA.	2'-0"	4'-0"	6'-0"	8'-0"	12'-0"	16'-0"	19'-0"	20'-0"	24'-0"	28'-0"	28'-0"	31'-0"
END	—	—	—	—	—	—	—	—	—	—	—	—
F.R.	—	—	—	—	—	—	—	0-8½	1-3½	1-3½	2-9½	3-10½
¼	—	—	—	—	—	—	0-9½	4-2½	5-1½	5-10½	7-3½	8-0½
½	—	—	—	—	—	—	4-10½	6-3½	7-2½	7-10½	8-7½	9-2½
¾	—	—	—	—	—	—	7-2½	8-0½	8-7½	8-10½	9-3½	9-6½
1	1-6½	2-8½	3-11½	5-1½	6-3½	7-2½	8-0½	8-3½	8-10½	9-1½	9-6½	9-9½
2	3-6½	5-1½	6-4½	7-4½	8-3½	8-10½	9-3½	9-4½	9-7½	9-9½	9-11½	10-0½
3	4-9½	6-3½	7-6½	8-4½	9-1½	9-6½	9-9½	9-10½	10-0½	10-1½	10-2½	10-3½
4	5-8½	7-0½	8-1½	8-10½	9-4½	9-8½	10-0½	10-1½	10-2½	10-3½	10-4½	10-5½
5	6-5½	7-8½	8-7½	9-2½	9-7½	9-10½	10-1½	10-2½	10-3½	10-4½	10-5½	10-6½
6	6-9½	7-11½	8-10½	9-4½	9-9½	10-0½	10-2½	10-3½	10-4½	10-5½	10-6½	10-6½
7	7-1½	8-2½	9-0½	9-6½	9-10½	10-1½	10-3½	10-4½	10-5½	10-6½	10-6½	10-6½
8	7-5½	8-5½	9-2½	9-8½	10-0½	10-2½	10-4½	10-5½	10-6½	10-6½	10-6½	10-6½
9	7-8½	8-8½	9-4½	9-9½	10-1½	10-3½	10-5½	10-6½	10-6½	10-6½	10-6½	10-6½
10	8-0½	8-10½	9-6½	9-11½	10-2½	10-4½	10-6½	10-6½	10-6½	10-6½	10-6½	10-6½
11	8-3½	9-0½	9-8½	10-0½	10-3½	10-5½	10-6½	10-6½	10-6½	10-6½	10-6½	—
12	8-6½	9-2½	9-10½	10-1½	10-4½	10-6½	10-6½	10-6½	10-6½	10-6½	10-6½	—
13	8-9½	9-4½	9-11½	10-2½	10-5½	10-6½	10-6½	10-6½	10-6½	10-6½	—	—
14	9-0½	9-6½	10-0½	10-3½	10-6½	10-6½	10-6½	10-6½	10-6½	10-6½	—	—
15	9-3½	9-8½	10-1½	10-4½	10-6½	10-6½	10-6½	10-6½	10-6½	—	—	—
16	9-6½	9-10½	10-2½	10-5½	10-6½	10-6½	10-6½	10-6½	10-6½	—	—	—
17	9-9½	9-11½	10-3½	10-6½	10-6½	10-6½	10-6½	10-6½	—	—	—	—
18	9-10½	10-1½	10-4½	10-6½	10-6½	10-6½	10-6½	—	—	—	—	—
18½	—	10-2½	10-5½	10-6½	10-6½	10-6½	10-6½	—	—	—	—	—
19	—	—	—	—	0-0½	7-2½	7-6½	7-6½	7-6½	7-6½	—	—
19½	—	—	—	—	—	—	2-7½	2-1½	1-7½	1-7½	—	—
A.P.	—	—	—	—	—	—	—	0-1½	0-1½	0-1½	—	—
TRAN.	—	—	—	—	—	—	—	6-7½	8-0½	8-7½	—	—

OFFSET TABLES

BUTTOCKS
HEIGHTS

STA.	1'-0"	2'-0"	4'-0"	6'-0"	8'-0"	12'-0"	18'-0"	20'-0"
END	—	—	—	—	—	—	—	—
F.R.	13'-1	12'-6½	11'-5½	10'-5½	9'-6½	8'-0½	6'-0½	4'-6½
¼	13'-7½	13'-0½	12'-0½	11'-0½	10'-2½	8'-8½	6'-8½	5'-2½
½	14'-2½	13'-7½	12'-7½	11'-8½	10'-10½	9'-5½	7'-5½	5'-11½
¾	14'-8½	14'-2½	13'-2½	12'-3½	11'-5½	10'-0½	8'-0½	6'-6½
1	15'-0½	14'-5½	13'-5½	12'-6½	11'-8½	10'-3½	8'-3½	6'-9½
2	15'-3½	14'-8½	13'-8½	12'-9½	11'-11½	10'-6½	8'-6½	7'-0½
3	15'-4½	14'-9½	13'-9½	12'-10½	12'-0½	10'-7½	8'-7½	7'-1½
4	15'-5½	14'-10½	13'-10½	12'-11½	12'-1½	10'-8½	8'-8½	7'-2½
5	15'-6½	14'-11½	13'-11½	13'-0½	12'-2½	10'-9½	8'-9½	7'-3½
6	15'-7½	15'-0½	14'-0½	13'-1½	12'-3½	10'-10½	8'-10½	7'-4½
7	15'-8½	15'-1½	14'-1½	13'-2½	12'-4½	10'-11½	8'-11½	7'-5½
8	15'-9½	15'-2½	14'-2½	13'-3½	12'-5½	11'-0½	9'-0½	7'-6½
9	15'-10½	15'-3½	14'-3½	13'-4½	12'-6½	11'-1½	9'-1½	7'-7½
10	15'-11½	15'-4½	14'-4½	13'-5½	12'-7½	11'-2½	9'-2½	7'-8½
11	16'-0½	15'-5½	14'-5½	13'-6½	12'-8½	11'-3½	9'-3½	7'-9½
12	16'-1½	15'-6½	14'-6½	13'-7½	12'-9½	11'-4½	9'-4½	7'-10½
13	16'-2½	15'-7½	14'-7½	13'-8½	12'-10½	11'-5½	9'-5½	7'-11½
14	16'-3½	15'-8½	14'-8½	13'-9½	12'-11½	11'-6½	9'-6½	8'-0½
15	16'-4½	15'-9½	14'-9½	13'-10½	13'-0½	11'-7½	9'-7½	8'-1½
16	16'-5½	15'-10½	14'-10½	13'-11½	13'-1½	11'-8½	9'-8½	8'-2½
17	16'-6½	15'-11½	14'-11½	14'-0½	13'-2½	11'-9½	9'-9½	8'-3½
18	16'-7½	16'-0½	15'-0½	14'-1½	13'-3½	11'-10½	9'-10½	8'-4½
18½	16'-8½	16'-1½	15'-1½	14'-2½	13'-4½	11'-11½	9'-11½	8'-5½
19	16'-9½	16'-2½	15'-2½	14'-3½	13'-5½	12'-0½	10'-0½	8'-6½
19½	16'-10½	16'-3½	15'-3½	14'-4½	13'-6½	12'-1½	10'-1½	8'-7½
A.P.	16'-11½	16'-4½	15'-4½	14'-5½	13'-7½	12'-2½	10'-2½	8'-8½
TRAN.	16'-11½	16'-4½	15'-4½	14'-5½	13'-7½	12'-2½	10'-2½	8'-8½

STA.	UPPER DECK HT. AT C.	UPPER DECK HT. SIDE	MAIN DECK HT. AT C.	MAIN DECK HT. SIDE	MAIN DECK SHEER HEIGHT	2ND DECK HEIGHT	PLATFORM SHEER HEIGHT	PLATFORM SHEER HEIGHT
END	40'-0½	39'-0½	—	—	31'-11½	29'-0½	—	—
F.R.	39'-9½	39'-1½	31'-0½	31'-0½	31'-0½	29'-0½	27'-6½	26'-0½
¼	39'-7½	39'-0½	31'-0½	31'-0½	31'-0½	29'-0½	27'-6½	26'-0½
½	39'-4½	38'-10½	31'-0½	31'-0½	31'-0½	29'-0½	27'-6½	26'-0½
¾	39'-2½	38'-8½	31'-0½	31'-0½	31'-0½	29'-0½	27'-6½	26'-0½
1	39'-0½	38'-6½	31'-0½	31'-0½	31'-0½	29'-0½	27'-6½	26'-0½
2	38'-7½	38'-1½	30'-7½	30'-7½	30'-7½	28'-9½	27'-3½	25'-9½
3	38'-4½	37'-10½	30'-4½	30'-4½	30'-4½	28'-6½	27'-0½	25'-6½
4	38'-1½	37'-7½	30'-1½	30'-1½	30'-1½	28'-3½	26'-9½	25'-3½
5	37'-10½	37'-4½	29'-10½	29'-10½	29'-10½	28'-0½	26'-6½	25'-0½
6	37'-7½	37'-1½	29'-7½	29'-7½	29'-7½	27'-9½	26'-3½	24'-9½
7	37'-4½	36'-10½	29'-4½	29'-4½	29'-4½	27'-6½	26'-0½	24'-6½
8	37'-1½	36'-7½	29'-1½	29'-1½	29'-1½	27'-3½	25'-9½	24'-3½
9	36'-10½	36'-4½	28'-10½	28'-10½	28'-10½	27'-0½	25'-6½	24'-0½
10	36'-7½	36'-1½	28'-7½	28'-7½	28'-7½	26'-9½	25'-3½	23'-9½
11	36'-4½	35'-10½	28'-4½	28'-4½	28'-4½	26'-6½	25'-0½	23'-6½
12	36'-1½	35'-7½	28'-1½	28'-1½	28'-1½	26'-3½	24'-9½	23'-3½
13	35'-10½	35'-4½	27'-10½	27'-10½	27'-10½	26'-0½	24'-6½	23'-0½
14	35'-7½	35'-1½	27'-7½	27'-7½	27'-7½	25'-9½	24'-3½	22'-9½
15	35'-4½	34'-10½	27'-4½	27'-4½	27'-4½	25'-6½	24'-0½	22'-6½
16	35'-1½	34'-7½	27'-1½	27'-1½	27'-1½	25'-3½	23'-9½	22'-3½
17	34'-10½	34'-4½	26'-10½	26'-10½	26'-10½	25'-0½	23'-6½	22'-0½
18	34'-7½	34'-1½	26'-7½	26'-7½	26'-7½	24'-9½	23'-3½	21'-9½
18½	34'-4½	33'-10½	26'-4½	26'-4½	26'-4½	24'-6½	23'-0½	21'-6½
19	34'-1½	33'-7½	26'-1½	26'-1½	26'-1½	24'-3½	22'-9½	21'-3½
19½	33'-10½	33'-4½	25'-10½	25'-10½	25'-10½	24'-0½	22'-6½	21'-0½
A.P.	33'-7½	33'-1½	25'-7½	25'-7½	25'-7½	23'-9½	22'-3½	20'-9½
TRAN.	33'-7½	33'-1½	25'-7½	25'-7½	25'-7½	23'-9½	22'-3½	20'-9½

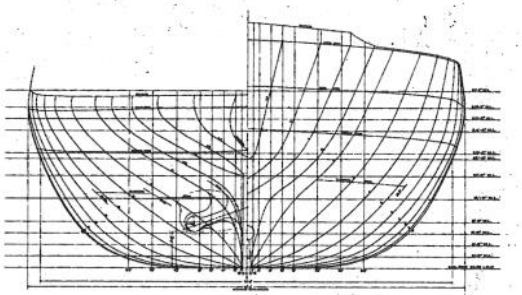


CAMBER CURVE FOR UPPER DECK & DECKS ABOVE UPPER DECK

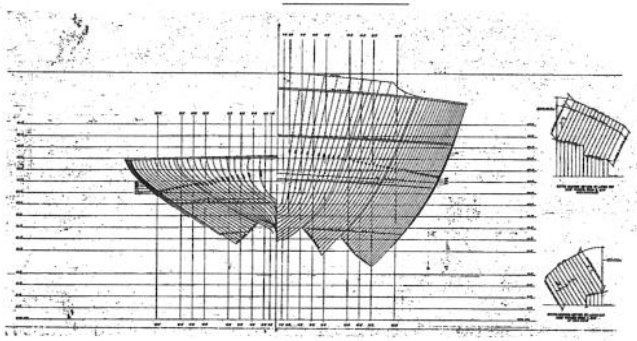
SCALE: 1/4" = 1'-0"

CAMBER CURVE FOR MAIN DECK

SCALE: 1/4" = 1'-0"

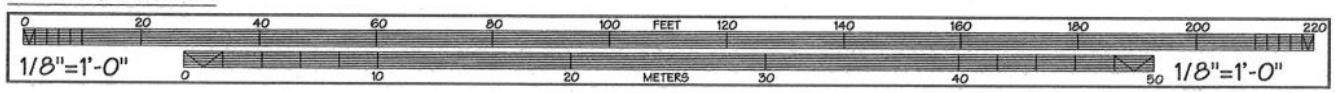


BODY PLAN



FRAMING PLAN

LINES PLAN



NOTE: SCANS FROM ORIGINAL 1943 CONSTRUCTION PLANS BY THE USCG

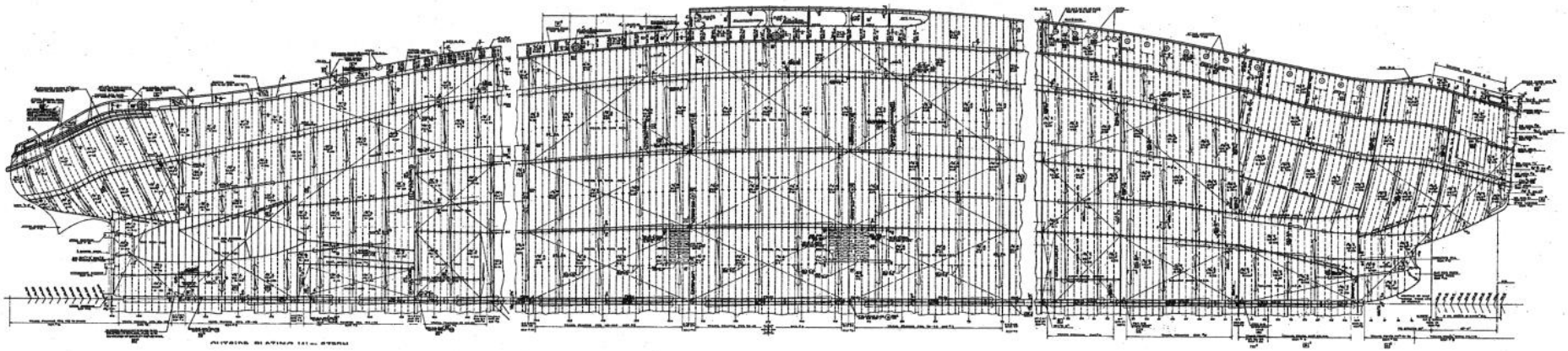
MACKINAW (WAGB 83)
CHEBOYGAN COUNTY
MICHIGAN

SHEET 7 OF 11

HISTORIC AMERICAN ENGINEERING RECORD
MI-121

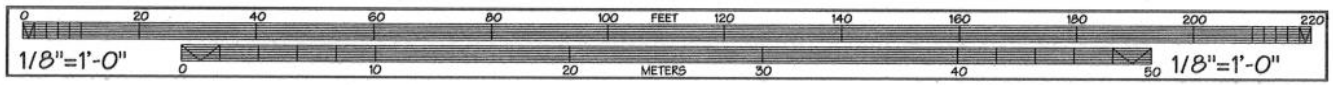
DELINEATED BY: GREGOIRE HALEYMAN
HABS MARITIME
RECORDING PROGRAM
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

CHEBOYGAN



SHELL EXPANSION PLAN

SHELL EXPANSION PLAN



NOTE: SCANS FROM ORIGINAL 1943 CONSTRUCTION PLANS BY THE USCG

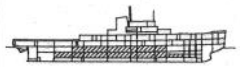
MACKINAW (WAGB 83)
U.S. COAST GUARD ICEBREAKER
CHEBOYGAN COUNTY
MICHIGAN

SHEET 8 OF 11

HISTORIC AMERICAN ENGINEERING RECORD MI-121

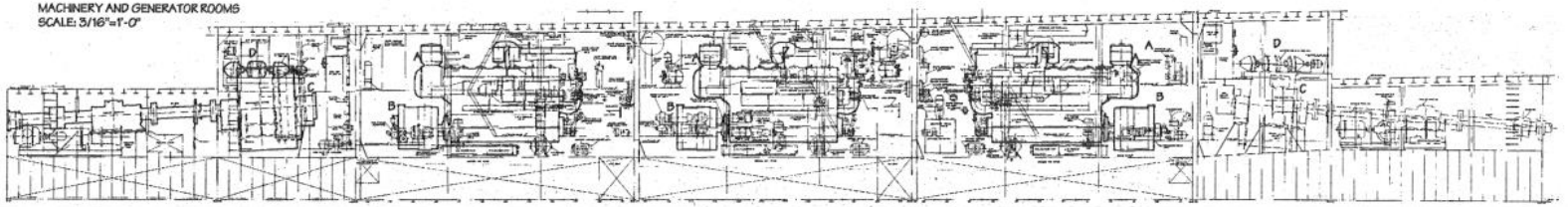
CHEBOYGAN

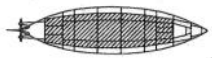
DELINEATED BY: GREGOIRE HOLEYMAN
HAER PHOTO
HISTORIC AMERICAN ENGINEERING RECORD
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR



INBOARD PROFILE

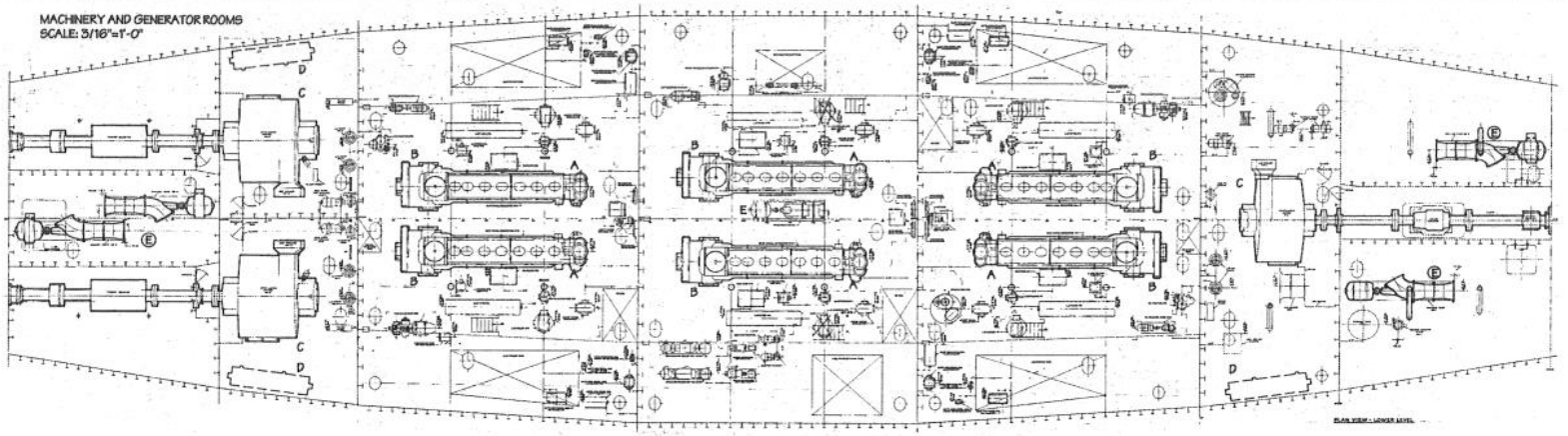
MACHINERY AND GENERATOR ROOMS
SCALE: 3/16"=1'-0"





HOLD

MACHINERY AND GENERATOR ROOMS
SCALE: 3/16"=1'-0"



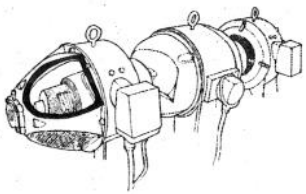
TRIM AND HEEL PUMPS:

NOTICE LOCATION OF HEEL AND TRIM PUMPS (E) IN PLAN. SEE SHEET #10 FOR MORE INFORMATION ON THIS SYSTEM.

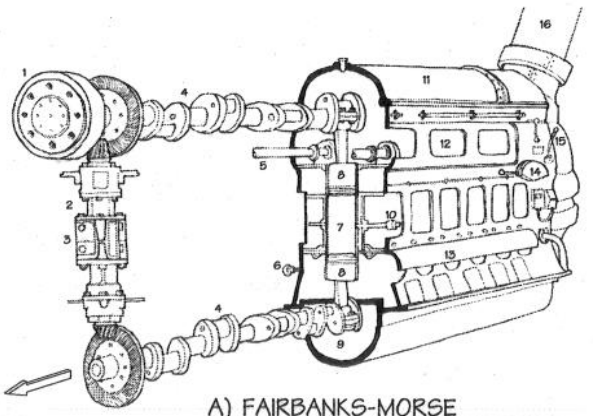
NOTE: SCANS FROM ORIGINAL 1943 CONSTRUCTION PLANS BY THE USCG

POWER AND PROPULTION SYSTEMS:

THE MACKINAW IS POWERED THROUGH A DIESEL-ELECTRIC SYSTEM. THE CORE POWER SUPPLY IS GENERATED FROM THE SIX FAIRBANKS-MORSE, 10 CYLINDER, OPPOSED-PISTON, DIESEL ENGINES; TWO EACH ARE LOCATED PER MACHINE ROOM. THE ENGINE WAS ORIGINALY DESIGNED FOR LOCOMOTIVE FUNCTIONS RESULTING IN THEIR NARROW AND TALL CONFIGUARTION. THE 2000 HP OF DIESEL MUSCLE IS TRANSFORMED INTO DC ELECTRIC ENERGY VIA THE WESTINGHOUSE GENERATOR ATTACHED TO THE END OF EACH ENGINE. THE GENERATOR CREATES 900 VOLTS AND 1530 AMPS OF DC ELECTRICITY. THE ELECTRIC CURRENT POWERS THE WESTINGHOUSE PROPULSION MOTORS WHICH ARE ATTACHED TO THE PROPELLOR SHAFTS. THE MOTOR'S MAGNETIC FIELD IS ESTABLISHED BY THE EXCITOR ENGINES. THE TWO AFT MOTORS GENERATE 5000 HP AND TURN THE PROPELLORS UP TO 136 RPM WHILE THE SMALLER BOW MOTOR SPINS THE SHAFT UP TO 175 RPM WHILE GENERATING 3300 HP; THE DIRECT DRIVE EFFECT MEANS THAT THE SHAFT SPINS AT THE SAME RATE AS THE MOTOR TURNS. THE SOLID STEEL PROPELLOR ARE 14 FT IN DIAMETER AT THE AFT AND 12 FT AT THE BOW.

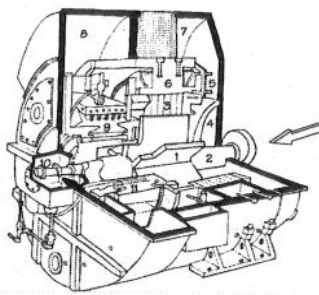


D) EXCITOR ENGINE



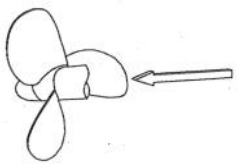
A) FAIRBANKS-MORSE OPPOSED-PISTON DIESEL ENGINE

1. BLOWER DRIVE GEAR
2. VERTICAL DRIVE
3. SPRING PACK
4. CRANKSHAFT
5. CAMSHAFT
6. PYROMETER
7. CYLINDER LINER
8. OPPOSED PISTON
9. OIL SUMP
10. BLOW DOWN
11. COFFIN COVER
12. INTAKE MANIFOLD
13. EXHAUSE MANIFOLD
14. STARTING LEVER
15. FUEL RESET LEVER
16. EXHAUST

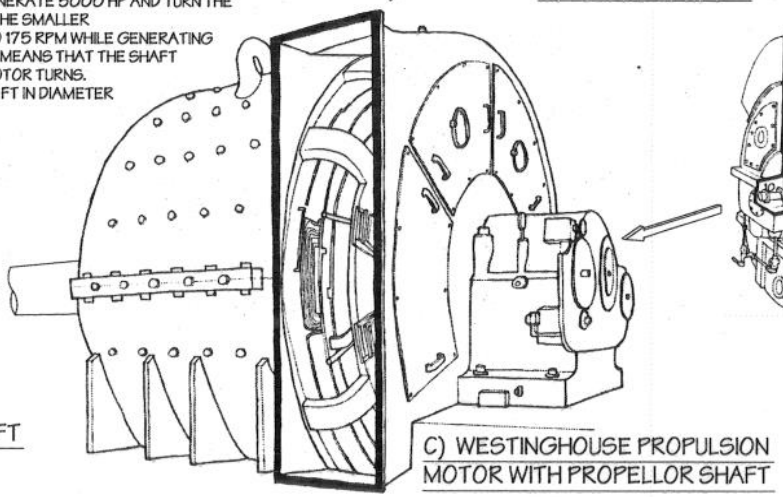


B) WESTINGHOUSE GENERATOR

1. ARMATURE SPIDER
2. ARMATURE SHAFT
3. ARMATURE CORE
4. ARMATURE WINDING
5. COMPENSATING WINDING
6. MAIN POLE LAMINATIONS
7. COOLER CORES
8. AIR DUCT
9. BRUSH HOLDER ASSEMBLY
10. SLEEVE BEARING
11. COMMUTATOR SEGMENTS



PROPELLOR WITH SHAFT



C) WESTINGHOUSE PROPULSION MOTOR WITH PROPELLOR SHAFT

MACKINAW (WAGB 83)
ICEBREAKING TUG
CHEBOYGAN COUNTY
MICHIGAN

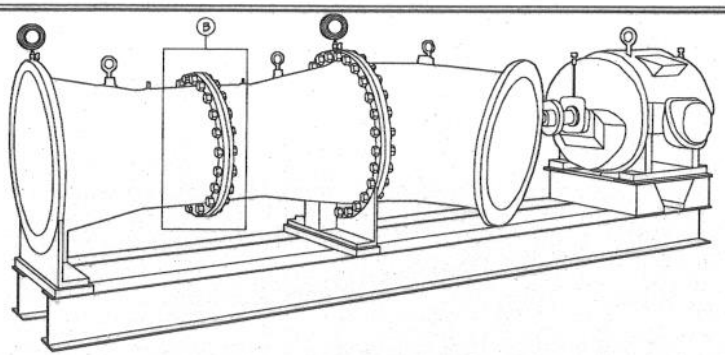
SHEET 9 OF 11

HISTORIC AMERICAN ENGINEERING RECORD
HAER MI-121

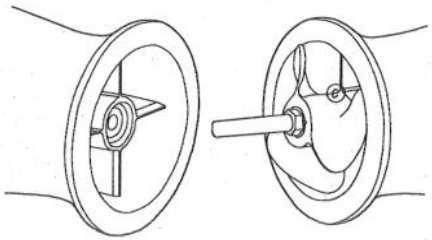
CHEBOYGAN

DELINEATED BY: GREGORIE HOLEMAN
HAER HABITAT RECORDING PROGRAM
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

HEELING AND TRIM SYSTEM

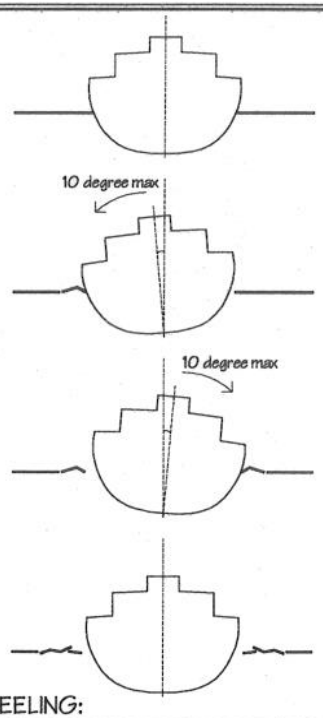


DETAIL A HEELING AND TRIMMING PUMPS:
REVERSIBLE PROPELLOR PUMP



DETAIL B PROPELLOR IN PIPE ASSEMBLY:
OUTER DIFFUSER HAS BEEN REMOVED

DETAIL C PROPELLOR ON SHAFT:
SHAFT SLEEVE HAS BEEN REMOVED. SHAFT IS ATTACHED TO WESTINGHOUSE MOTOR.

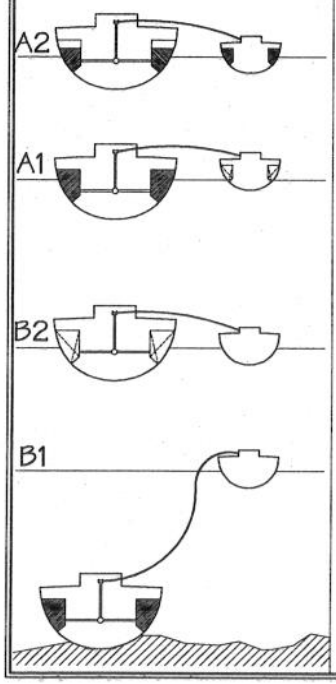


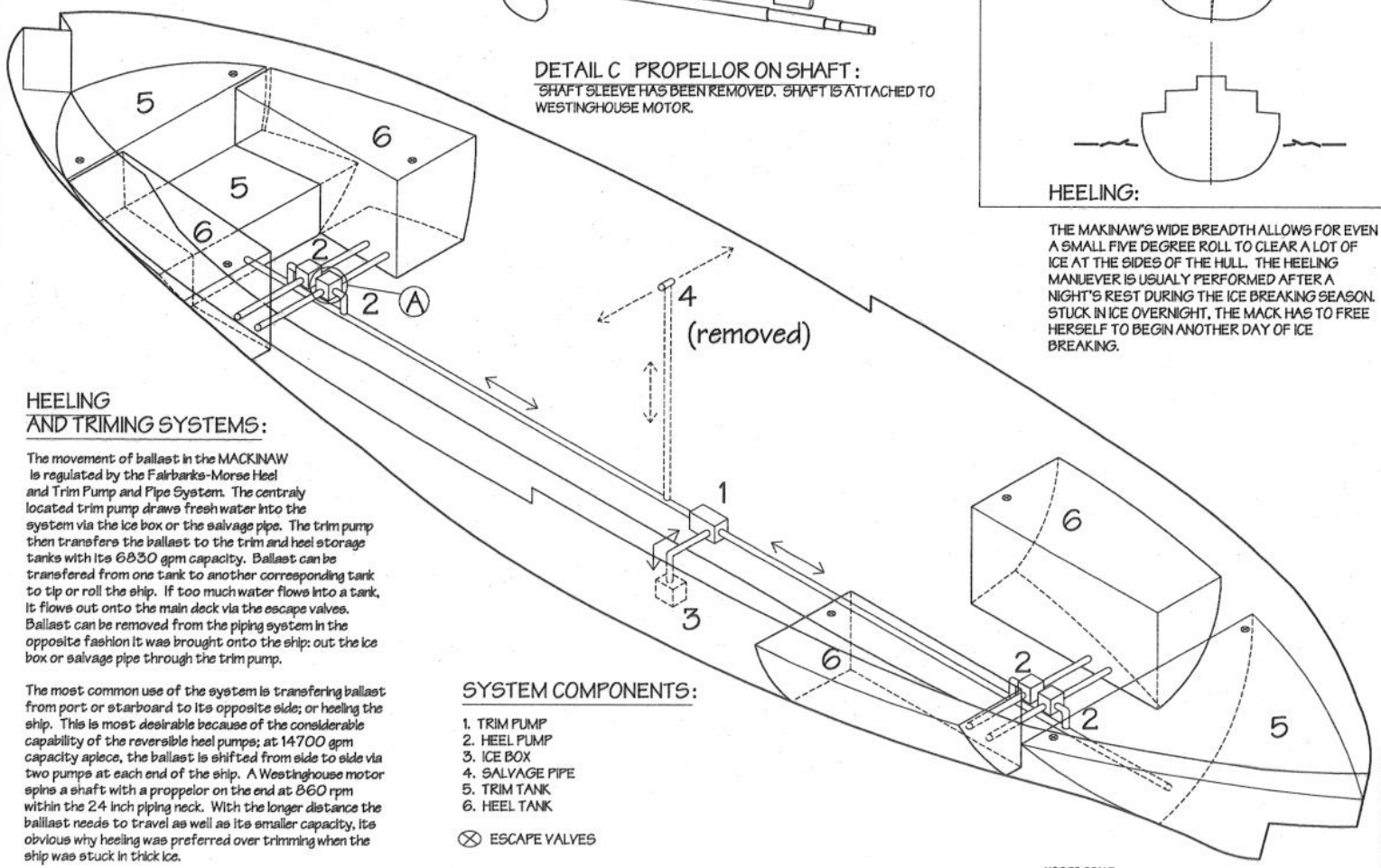
HEELING:

THE MAKINAW'S WIDE BREADTH ALLOWS FOR EVEN A SMALL FIVE DEGREE ROLL TO CLEAR A LOT OF ICE AT THE SIDES OF THE HULL. THE HEELING MANUEVER IS USUALY PERFORMED AFTER A NIGHT'S REST DURING THE ICE BREAKING SEASON. STUCK IN ICE OVERNIGHT, THE MACK HAS TO FREE HERSELF TO BEGIN ANOTHER DAY OF ICE BREAKING.

SALVAGE PIPE:

Removed sometime in the 1950's, the salvage pipe served a couple of functions. If another ship needed ballast (a1), the MACKINAW could transfer some of its water from the trim and heel tanks through the trim pump and some type of connection to the other ship (a2). This could also be reversed if the mack needed extra ballast herself. Another functon of the salvage pipe was to resurface the MACKINAW if she ever sunk (b1). A rescue ship could pump air into the trim and heel tanks (the air would force out the water through the escape valves). Theoreticaly, the air in the tanks would raise the sunken MACKINAW to the surface (b2).





HEELING AND TRIMING SYSTEMS:

The movement of ballast in the MACKINAW is regulated by the Fairbanks-Morse Heel and Trim Pump and Pipe System. The centraly located trim pump draws fresh water into the system via the ice box or the salvage pipe. The trim pump then transfers the ballast to the trim and heel storage tanks with its 6830 gpm capacity. Ballast can be transfered from one tank to another corresponding tank to tip or roll the ship. If too much water flows into a tank, it flows out onto the main deck via the escape valves. Ballast can be removed from the piping system in the opposite fashion it was brought onto the ship: out the ice box or salvage pipe through the trim pump.

The most common use of the system is transfering ballast from port or starboard to its opposite side; or heeling the ship. This is most desirable because of the considerable capability of the reversible heel pumps; at 14700 gpm capacity apiece, the ballast is shifted from side to side via two pumps at each end of the ship. A Westinghouse motor spins a shaft with a propeior on the end at 860 rpm within the 24 inch piping neck. With the longer distance the ballast needs to travel as well as its smaller capacity, its obvious why heeling was preferred over trimming when the ship was stuck in thick ice.

SYSTEM COMPONENTS:

1. TRIM PUMP
2. HEEL PUMP
3. ICE BOX
4. SALVAGE PIPE
5. TRIM TANK
6. HEEL TANK

⊗ ESCAPE VALVES

NOT TO SCALE

MACKINAW (WAGB 83)
1ST COAST GUARD DISTRICT
CHEBOYGAN COUNTY
MICHIGAN

CHEBOYGAN

HISTORIC AMERICAN ENGINEERING RECORD
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SHEET 10 OF 11

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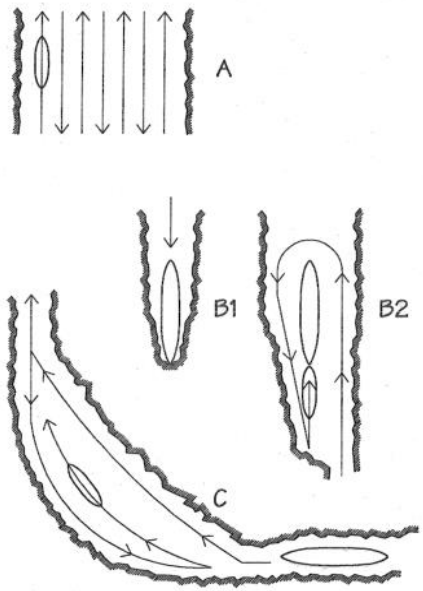
FUNCTIONAL CHARACTERISTICS



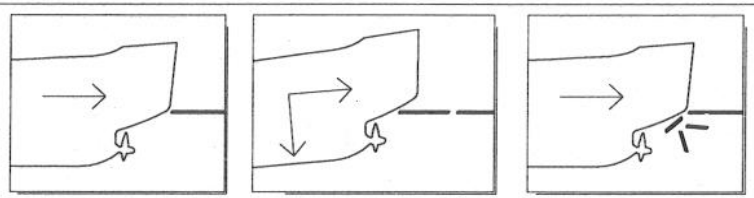
ICE BREAKING MANUEVERS:

THE SHIPPING CORRIDORS ARE KEPT RUNNING DURING THE ICE SEASON THROUGH DIFFERENT TECHNIQUES.

A) A "SUPERHIGHWAY" IS CREATED BY HAVING THE MACKINAW CLEAR A WIDE PATH THROUGH THE ICE FIELDS.

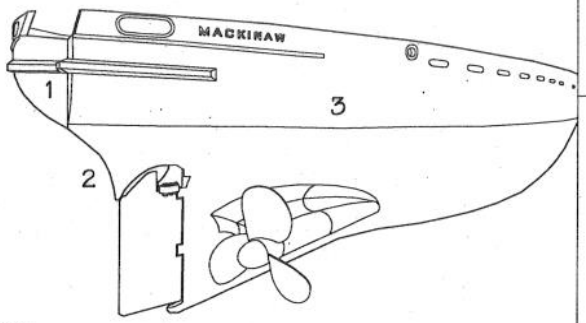
B) WHEN A LAKER IS STUCK IN ICE (B1), THE MACKINAW PERFORMS THE "CRAB WALK" TO FREE THE SHIP. THE MACKINAW CIRCLES THE SHIP, CLEARING THE SURROUNDING ICE, AND SLOWLY BACKS INTO THE BOW OF THE TRAPPED CARRIER WHILE IN FULL THROTTLE, CAUSING PROP WASH TO PASS ALONG THE SIDES OF THE CARRIER AND PUSHES AWAY ANY STUCK ICE (B2). DURING THIS MANUEVER, THE BOUNCE-CUSHION EFFECT OF THE SOLID ICE CAUSES THE MACK TO BACK UP IN A CRAB WALK FASHION. ONCE THE MACK IS IN POSITION, THE SHIP IS TOWED THE REST OF THE WAY.

C) FOR LONG SHIPS, A WIDE TURNING RADIUS IS CREATED BY FIRST PROCEEDING ALONG THE INSIDE CURVE, THEN BACKING DOWN ALONG THE OUTSIDE CURVE AND FINALY DOWN THE MIDDLE OF THE TURN.



MAIERFORM BOW:

THE SHAPE OF THE BOW LENDS ITSELF TO ICEBREAKING. WITH THE THRUST OF ROARING ENGINES PUSHING THE SHIP INTO THE ICE, THE ANGLED RAKE OF THE BOW IS DESIGNED TO RAISE THE SHIP OVER THE ICE UPON CONTACT. WITH THE ADDED WEIGHT OF FULL TRIM AND HEEL TANKS, THE MACKINAW FALLS AND CRUSHES ANY ICE UNDERNEATH ITS HULL. THIS MOTION IS REPEATED TO CREATE A SEAM IN THE ICE SHELF .



1) V-NOTCH:

THE MACKINAW'S STERN HAS A NOTCH TO ACCOMODATE A TOWED SHIP. THE SHAPE IS INTENDED FOR A CLOSE, BUT COMFORTABLE DISTANCE IN WHICH A SHIP CAN BE SAFELY TOWED.

2) RUDDER HORN:

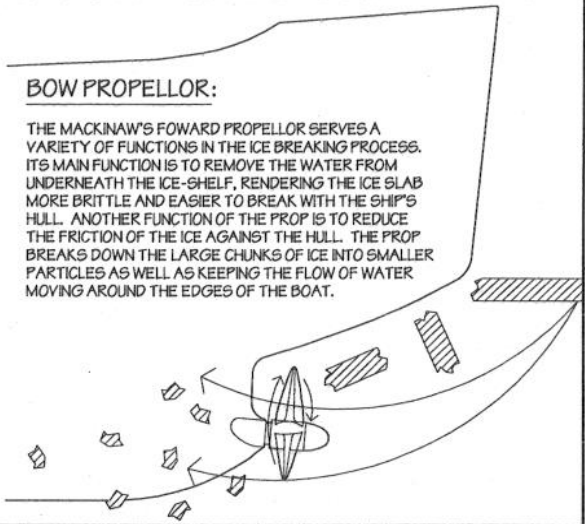
THE RUDDER HORN DEFLECTS ICE AS THE MACK IS BACKING UP. THE STEEL IS CAST FROM ONE LARGE MOLD AND ITS SHAPE IS EFFECTIVE AT ICE BREAKING WHILE MOVING BACKWARDS.

3) ICE BELT:

THE ICE BELT HELPS TO PROTECT THE SHIP FROM DAMAGE. ALONG THE WATERLINE, THE SHIP IS MADE OF WELDED 1-3/8" THICK HIGH-TENSILE STEEL. BELOW THE WATERLINE, THE HULL IS LAYED WITH 1-5/8" THICK MILD STEEL; BETTER SUITED FOR THE FRIGID WATERS OF THE ICE BREAKING SEASON.

BOW PROPELLOR:

THE MACKINAW'S FOWARD PROPELLOR SERVES A VARIETY OF FUNCTIONS IN THE ICE BREAKING PROCESS. ITS MAIN FUNCTION IS TO REMOVE THE WATER FROM UNDERNEATH THE ICE-SHELF, RENDERING THE ICE SLAB MORE BRITTLE AND EASIER TO BREAK WITH THE SHIP'S HULL. ANOTHER FUNCTION OF THE PROP IS TO REDUCE THE FRICTION OF THE ICE AGAINST THE HULL. THE PROP BREAKS DOWN THE LARGE CHUNKS OF ICE INTO SMALLER PARTICLES AS WELL AS KEEPING THE FLOW OF WATER MOVING AROUND THE EDGES OF THE BOAT.



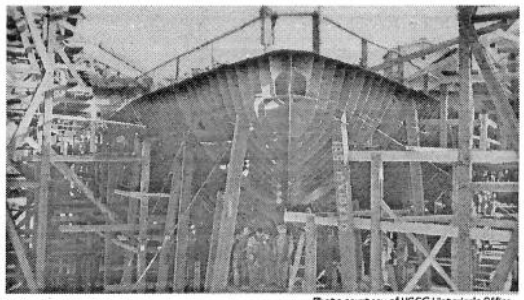
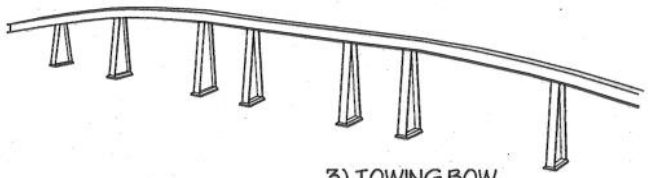


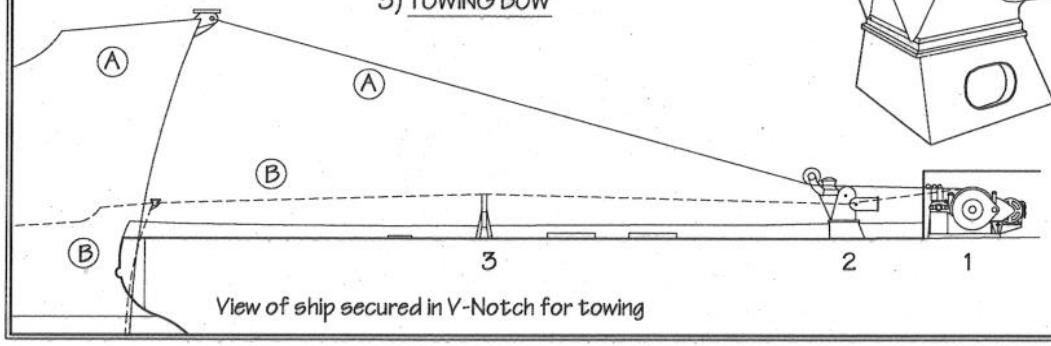
Photo courtesy of USCG Historian's Office

BOW FRAMING:

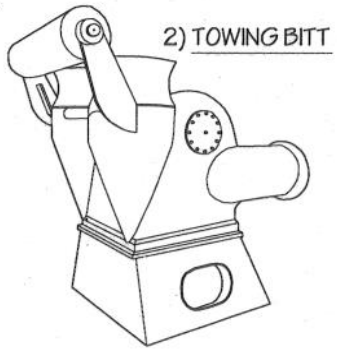
THE CANTILEVERED STEEL FRAMING OF THE BOW IS REINFORCED BY THE 16 SPACING BETWEEN FRAMES. THE VAST AMOUNT OF STRUCTURAL STEEL HAS BEEN PIVOTAL IN KEEPING THE MACKINAW IN SERVICE FOR OVER 60 YEARS.



3) TOWING BOW



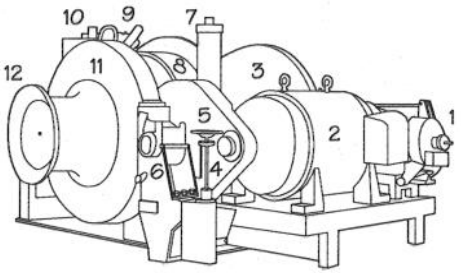
View of ship secured in V-Notch for towing



2) TOWING BITT

TOWING:

THE MACKINAW IS EQUIPED WITH HEAVY DUTY TOWING CAPABILITIES. THE ALMAN JOHNSON AUTOMATIC ELECTRIC TOWING MACHINE CAN PULL UP TO 94,000 LBS. THE LINE IS FED THROUGH THE PULLEY OF THE TOWING BIT. ALSO KNOWN AS "THE OLD LADY," THE MULTI-FUNCTIONAL BIT CAN ACCOMODATE DIFFERENT TOWING ARRANGEMENTS AS SHOWN IN LINE ARRANGEMENT "A" FOR TALL SHIPS. THE TOWING BOW KEEPS THE LINE FROM SNAGGING ANY EQUIPMENT ON THE DECK WHEN TOWING SMALLER SHIPS AS SHOWN IN LINE ARRANGEMENT "B."



1) ALMAN JOHNSON AUTOMATIC ELECTRIC TOWING MACHINE

1. SOLENOID BRAKE
2. MARINE MOTOR
3. TOWING HAWSER DRUM
4. TENSION ADJUSTER STAND
5. MOTOR GEAR & PINION
6. INTERMEDIATE BEARING STAND
7. VERTICAL SPRING CASE
8. CLUTCH-BRAKE BAND
9. CLUTCH-BRAKE COMPRESSOR
10. VERTICAL SPRING CASE
11. BULL GEAR
12. GYPSY HEAD

MACKINAW (WAGB 83)
CHEBOYGAN COUNTY
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SHEET 11 OF 11

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